National Defense Industrial Association
Integrated Program Management Division

Planning & Scheduling Excellence Guide (PASEG)

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Revision Log

Version	Date	Change Summary/Notes
Version 1.0	11/5/2010	Released for NDIA Program Planning and Scheduling Subcommittee (PPSS) Member Content Review
Version 1.1	2/11/2011	General Communications Release
Version 1.1a	2/24/2011	Minor administrative changes to v1.1
Version 1.1b	4/6/2011	Public Release for review and comment
Version 2.0	6/22/2012	Public Release following one-year public review period. PASEG ownership transferred to the NDIA PMSC/IPMD.
Version 3.0	4/12/2016	Public Release following three-month public review period.
Version 4.0	9/12/2019	Public Release following 30-day public review period.

1 Planning & Scheduling Excellence Guide (PASEG) Purpose and Scope

Description

This guide provides the program management team, including new and experienced planner/schedulers, with practical approaches for building, using, and maintaining an Integrated Master Schedule (IMS). It also identifies knowledge, awareness, and processes that enable the user to achieve reasonable consistency and a standardized approach to project planning, scheduling and analysis.

Sound schedules merge cost and technical data to influence program management decisions and actions. Realistic schedules help stakeholders make key go-ahead decisions, track and assess past performance, and predict future performance and costs. Industry and Government agree that improving IMS integrity has a multiplier effect on improved program management. Program teams can benefit from this guide to gain a common understanding of key scheduling terms, concepts, and practices. The guide also provides practical tips and caveats for scheduling techniques that apply for any scheduling software tool or environment. Using this guide, the program team can build and maintain more robust and dynamic schedules that provide a roadmap for improved program execution.

By capturing the extensive knowledge of experienced Government and Industry professionals, this guide provides how-to direction or instruction. This document aims to translate earned value or scheduling policy and guidance into practical approaches for improving scheduling capabilities and outputs across Government and Industry. Though written primarily for the DoD/Intel community, this guide provides scheduling practices or techniques that apply to any industry. Still, the primary focus is on scheduling for large programs with high technical, schedule, and cost risks. These programs stand to gain the most return on investment when all stakeholders dedicate the proper skills, resources, and time to developing and maintaining excellent schedules that pay high dividends for all parties.

Caveat throughout the Guide: The Microsoft Project screenshots are for demonstration purposes only and don't advocate the use of one tool over another.

Layout

The guide is divided into 13 major sections and appendices outlined in the table below.

PASEG Major Section	Description
1. Purpose and Scope	General overview of the IMS Guide purpose and scope.
2. GASP	The Generally Accepted Scheduling Principles (GASP) are eight over-arching tenets for building, maintaining, and using schedules as effective management tools.
3. Leadership, Buy-In, and Commitment	Includes Managing Using the IMS, The IMS is a Tool not Just a Report, Integration of Management Tools, and Roles and Responsibilities of Program Personnel.
4. Schedule Architecture	Explains IMS Architecture, Schedule Hierarchy and Top-Down v. Bottom-Up planning.

PASEG Major Section	Description
5. Standard Modeling Techniques	In depth exploration of IMS task naming conventions, duration, relationships/logic, lead/lag, constraints, milestones, summaries and hammocks, level of effort, apportioned effort, and working calendars. Additionally, explains the schedule calculation algorithm and options for modeling scheduling margin.
6. Cost and Schedule Resource Integration	Covers schedule with resources in the IMS and resources not in the IMS.
7. External Schedule Integration	Describes methods of incorporating external schedule information in the IMS including an overview of Subproject/External Schedule Integration, Interface Hand-off Milestones and Schedule Visibility Tasks.
8. Horizontal and Vertical Traceability	Defines and provides methods of maintaining vertical and horizontal traceability and an overview of task coding.
9. Schedule Maintenance	Discusses status updates, including status updating to Time Now, forecasting, and estimates at complete (EAC). Covers baseline maintenance, including the baseline change management process and the rolling wave process.
10. Schedule Analysis	Covers schedule health assessments, Critical and Driving path analysis, Schedule Risk Assessment (SRA) Set-Up and Execution, SRA Analysis, and incorporating Risk and Opportunities in the IMS. Addresses schedule execution metrics, including Critical Path Length Index (CPLI), Baseline Execution Index (BEI), Schedule Performance Index (SPI), Duration Based v. Scope Based % Complete, Schedule Rate Chart, and Current Execution Index (CEI).
11. Business Rhythm and Submittal	Includes IMS related documentation recommendations in IMS Supplemental Guidance and Desktop Procedures in addition to considerations for Program Schedule Reviews, IMS Submittal, and the IMS related program Business Rhythm.
12. Training	Covers recommended content for IMS related leadership and planner/schedule skills and training.
13. Program and Contract Phase Considerations	Describes various IMS attributes by program / contract phase (e.g. Technology Demonstration and Engineering, Manufacturing Development) and an in-depth explanation of Scheduling in a Production Environment.
Appendices	Includes the following four appendices: Terms and Definitions, References, GASP to PASEG Roadmap, and Credits and Acknowledgements

Figure 1-1 List of PASEG Major Sections

Each section listed in the Table of Contents contains more detailed chapters, each with a standard format described below.

With few exceptions, each chapter in this guide contains eight headings to enhance ease of use, navigation, and readability. Depending on the reader's role or purpose when using the guide, the chapter headings will help focus the reader on key points, tips, options, pros and cons, and references to other sections or chapters in this guide. The next table summarizes these chapter headings and when and how to use them.

PASEG Chapter Heading	When and How to Use It
Manager's View	Executives, program managers, and others can quickly find why this topic matters to managers. Describes how the concept or approach might impact IMS validity, decision-making capability, or other management values.
Description	More detailed description or discussion on the topic. Scheduling professionals, analysts, or the program team can find details – sometimes quite technical – on how and when to use this approach.
Example	As applicable, includes screenshots, tables, charts, or other depictions to clarify or enhance the discussion or to illustrate the technique or approach.
Calculations	When the topic impacts how scheduling tools calculate or process data, this section describes the key points. This is particularly important for scheduling professionals who seek to understand how and why certain techniques or functions might impact total float, durations, critical path, or impacts from other scheduling tool calculations.
Optional Techniques	Where appropriate, describes one or more alternative approaches that a program team might use, considering degree of difficulty, risk, and caveats.
Things to Promote	Whenever possible, this section will highlight processes or steps to follow to promote improved scheduling processes, information, or usefulness.
Things to Avoid	If applicable, lists techniques or processes to avoid, minimize, or mitigate, expressing the caveats, warnings, or potential pitfalls.
Related Topics	As applicable, lists the top three (sometimes more) related major sections or topics within this guide.

Figure 1-2 List of PASEG Chapter Headings

PASEG Background

The PASEG was a product produced by the Program Planning and Scheduling Subcommittee (PPSS). The PPSS was chartered by the Industrial Council for Program Management (ICPM) to develop and institute standardized scheduling processes across Industry and Government. The ICPM is a working group within the National Defense Industrial Association (NDIA).

The outline for the PASEG was drafted with advice and input from various planning and scheduling subject matter experts (SMEs) within Government and Industry. The starting point for the draft was a June 2009 draft of the NDIA Program Management Systems Committee (PMSC) Scheduling Intent Guide Table of Contents. The scheduling Intent Guide was drafted with the intent of providing sound practices for the construction, maintenance, and analysis of Integrated Master Schedules and as a supplemental guide to the DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide (v 0.9 Oct 21, 2005). The ownership of the PASEG was transferred to the NDIA PMSC in 2012. The PMSC was renamed to the Integrated Program Management Division (IPMD) in 2014.

The PASEG is subordinate to the requirements defined in the EIA-748 Guidelines, EVMS Interpretation Guide (EVMSIG), DI-MGMT-81650 (IMS DID), Integrated Program Management Report (IPMR) DID, contractor's approved System Description, and the contract's IMS CDRL when the EVM clause is applied to DoD contracts.

Recommendations for Use

Use this guide as a reference. In the scheduling arena, each organization or program might assess a topic and make minor adjustments to the approach with the primary aim of generating useful IMS data that helps to better inform management to aid in making decisions and taking actions. Try different approaches when the likely result is better, timelier, or more accurate management information. Share the approach for subsequent versions of this document. Use the Generally Accepted Scheduling Principles, GASP, to arbitrate contentious techniques. The guide is only useful if used with positive intent to produce improved schedules. Organizations and program teams must exercise judgment and follow practices that make sense for their programs and that result in improved program management information and decision-making that are in alignment with their company approved System Description or management procedures (as applicable).

Approaches should only be implemented if they are sustainable, given the organization or program complexity or the program team skills, experience, and capabilities. Use techniques that are realistic for the program team to implement and maintain while minimizing management process risks.

Since this guide should only be used as a reference, it is recommended that each program develops an IMS Supplemental Guidance that clarifies and specifies the uniqueness of the program approach (architecture, ground rules and assumptions, specific methodologies used for generating or analyzing the critical path, the business rhythm for updating the IMS, data dictionary, nomenclature, etc.). Refer to the IMS Supplemental Guidance chapter in the PASEG for additional details.

In particular, the sections in the Guide titled "Things to Promote" and "Things to Avoid" are recommended actions intended to promote better planning practices and improve planning products and uses.

Avoid rejecting approaches simply because they are new, "not-invented here." Consider that this guide was written by many authors who have a stake in improving scheduling capabilities and competencies, as well as program technical, cost, and schedule performance. If a technique truly seems incorrect or unsound, provide adequate feedback to enable improving the topic write-up in a subsequent version of the guide.

Recommendations for changes to the Guide should be directed to the Chair of the NDIA IPMD.

2 Generally Accepted Scheduling Principles (GASP)

Description

The Generally Accepted Scheduling Principles (GASP) are eight over-arching tenets for building, maintaining, and using schedules as effective management tools. The GASP is concise and easily understood yet sets high expectations for program management teams to develop and use schedules. The first five GASP tenets describe the requisite qualities of a valid schedule; that is, one that provides complete, reasonable, and credible information based on realistic logic, durations, and dates. The latter three GASP tenets reflect increased scheduling maturity that yields an effective schedule. An effective schedule provides timely and reliable data, aligns time-phased resources, and is built and maintained using controlled and repeatable processes.

The GASP serves several purposes. First, they are high level tenets, or targets, for sound scheduling. The GASP also serves as a validation tool for the program team or organization to assess IMS maturity or IMS areas needing improvement. Lastly, the GASP can be used as a governance tool to assess new or different scheduling approaches with objectivity and detachment.

Achieving a GASP-compliant IMS indicates the IMS is not merely healthy, but fit. A healthy IMS is functional and meets minimum management purposes, but a fit IMS is robust and dynamic. A fit IMS provides the program team with a program execution roadmap of meaningful progress and realistic forecasts against a resource-loaded performance measurement baseline. Thus, meeting all eight GASP tenets demonstrates that the program team builds and maintains the IMS with rigor and discipline so that the IMS remains a meaningful management tool from program start through completion.

The following tables show the eight Generally Accepted Scheduling Principles, including an “essential statement” and a more detailed narrative.

Generally Accepted Scheduling Principles (GASP)			GASP Narrative	GASP Essential Statement
Valid	1	Complete	Schedules represent all authorized effort for the entire contract, with essential subcontracted or other external work or milestones integrated yet distinguishable from internal work. Level of Effort may be excluded from the IMS.	The schedule captures the entire discrete, authorized project effort from start through completion.
	2	Traceable	Schedules reflect realistic and meaningful network logic that horizontally and vertically integrates the likely sequence for program execution. Schedules are coded to relate tasks or milestones to source or dependent documents, tools, and responsible organizations.	The schedule logic is horizontally & vertically integrated with cross-references to key documents & tools.
	3	Transparent	Schedules provide full disclosure of program status and forecast and include documented ground rules, assumptions, and methods for building and maintaining schedules. Documentation includes steps for analyzing the critical paths, incorporating risks and opportunities, and generating schedule health and performance metrics.	The schedule provides visibility to assure it is complete, traceable, has documented assumptions, & provides full disclosure of program status & forecast.
	4	Statused	Schedules reflect consistent and regular updates of completed work, interim progress, achievable remaining durations relative to the status date, and accurately maintained logic relationships.	The schedule has accurate progress through the status date.
	5	Predictive	Schedules accurately forecast the most likely completion dates and impacts to the program baseline plan through valid network logic and achievable task durations from the status date through program completion.	The schedule provides meaningful critical paths & accurate forecasts for remaining work through program completion.

Figure 2-1 GASP Principles – Valid Schedule

Generally Accepted Scheduling Principles (GASP)			GASP Narrative	GASP Essential Statement
Effective	6	Usable	Schedules produce meaningful metrics for timely and effective communication and tracking and improving performance, mitigating issues and risks, and capturing opportunities. Schedules are robust and functional to help stakeholders manage different levels, groupings, or areas as needed. Schedules are developed and maintained at a size, level, and complexity such that they are timely and enable effective decision-making.	The schedule is an indispensable tool for timely & effective management decisions & actions.
	7	Resourced	Resources align with the schedule baseline and forecast to enable stakeholders to view and assess the time-phased labor and other costs required to achieve project baseline and forecast targets. Each program is unique and uses varying techniques to load, baseline, and maintain the time-phased resources at levels that are practical and produce meaningful and accurate projections. When resource-loaded schedules are used they enable flexible updates to resource requirements as conditions change. Whether or not resource-loaded schedules are used, cost and schedule data are integrated for internal and external reporting.	The schedule aligns with actual & projected resource availability.
	8	Controlled	Schedules are baselined and maintained using a rigorous, stable, repeatable, and documented process. Schedule additions, deletions, and updates conform to this process and result in valid and accurate results for sound schedule configuration control and maintenance.	The schedule is built, baselined, & maintained using a stable, repeatable, & documented process.

Figure 2-2 GASP Principles – Effective Schedule

Figures 2-3 and 2-4 below demonstrate usage of the GASP for governance to compare options when considering different techniques or practices. The example below is merely a sample of how one might present the case for using (or not using) lag-values as a standard business practice. Each contractor/business could develop a business specific governance tool that can be used by program teams or organizations to help assess alignment to GASP. The aim here is to have the program team or scheduling professionals examine each scheduling approach scenario, and then assess ease of implementation and compliance to the GASP. With positive intent to objectively address each characteristic in the table, the program team can decide whether a given practice or technique is likely to improve the IMS. Answers will vary depending on the program size, complexity, risk, and duration as well as the capabilities and experience of the program team or schedulers. Where potential risks or issues arise, the program team should strive to mitigate them or possibly decide to forego the approach for a less risky alternative.

Note: the following tables (from the same tool model) should be considered representative examples only.

Practice or Method	Description of Practice or Method	Examples	< 7 No Go or More Risky >= 7 Go or Less Risky	COMPLIANCE TO GASP (positive impact) Complete	Traceable	Transparent	Statused	Predictive	Usable	Resourced	Controlled
Lag	Use lag values for wait time	Wait for paint to dry Waiting for customer review and approval or decision	5.4	High	Low	Low	Med	Med	Low	N/A	Low
Lag	Add Schedule Visibility Tasks (SVTs) instead of using lag for wait time	10 day SVT for paint to dry 20 day SVT for customer review and approval	9.6	High	High	High	High	High	High	N/A	High

Figure 2-3 Example of Planning Method to GASP Governance Model - Compliance

Practice or Method	Description of Practice or Method	Examples	< 7 No Go or More Risky >= 7 Go or Less Risky	EASE OF IMPLEMENTATION (may vary by organization or program) Documented?	Proven?	Simple?	Required Skills Exist?	No Training Required?	Data Valid?	Tool Support?	Notes Caveats Mitigations Tips Lessons Learned
Lag	Use lag values for wait time	Wait for paint to dry Waiting for customer review and approval or decision	5.4	High	High	High	High	Med	Low	High	+ Adding a lag is quick and easy - Extra discipline is required to provide rationale - Lag values can negatively effect metrics (additional investigation is required to verify the validity of the lag)
Lag	Add Schedule Visibility Tasks (SVTs) instead of using lag for wait time	10 day SVT for paint to dry 20 day SVT for customer review and approval	9.6	High	High	High	High	Med	High	High	+ "Wait" tasks behave like any other tasks - Durations still generally require external status input

Figure 2-4 Example of Planning Method to GASP Governance Model – Ease of Implementation

GASP Background

The GASP was originally developed as a governance mechanism for the Program Planning and Scheduling Subcommittee (PPSS). The PPSS was a subcommittee formed by the Industrial

Committee on Program Management (ICPM) working group under the auspices of the National Defense Industrial Association (NDIA). The GASP was developed collaboratively with inputs from both Government and Industry.

Recommendations for Use

Use the GASP as a governance tool when evaluating new scheduling processes, techniques, or tools. By assessing whether a new approach meets the GASP, the program team can readily arrive at a reasonable solution that minimizes any management process or other risks to producing valid and effective schedules. The GASP may also be used as a framework for training courses, for developing and using schedule information, for schedule reporting and analysis, and for writing program supplemental guidance.

It is essential to understand that the GASP is intentionally broad. The GASP set high expectations for excellent scheduling yet does not specify particular methodologies. Avoid viewing the GASP as dogma; instead, continually strive to meet or exceed the GASP with creative and practical approaches that work for the size, value, risk, and complexity of the program and the skills and capabilities of the program team. New practices or techniques are encouraged—if and when they meet the GASP. There will be times when a given practice diminishes compliance to one principle over another. This is expected and unavoidable, but what is paramount is that the program team weighs the benefits over the risks. When a practice negatively impacts a GASP tenet, the program team should take necessary steps to mitigate any management process risks that might diminish compliance with the GASP.

Program teams and organizations in both government and industry should remain flexible (within contractual requirements) and focused on placing improved management information above dogma or rigid application of the GASP or any other scheduling “standards” or “industry best practices”.

3 Leadership, Buy-in, and Commitment

This section contains the following chapters.

3.1 Managing Using the IMS

Manager's View

The primary purpose of any Integrated Master Schedule (IMS) is to help the Program Manager and the Program Team optimize the overall execution strategy of a program, coordinate workflows, and assist in the decision making processes to mitigate risks and resolve challenges on a day-to-day basis. As the IMS represents a predictive model of the entire program, it should be considered the focal point in the program management strategy. Program managers should recognize scheduling is a modeling process that helps communicate and coordinate ideas about what, when, and how things might occur in the future.

The bottom line is using an IMS will not guarantee success but operating without an effective schedule will increase the risk of missing program cost, schedule, and technical objectives.

Description

The IMS integrates cost, schedule, and technical performance into an interactive tool. Prior to the creation of the IMS, the Program Leadership team defines the management approach based on the program business culture, customer requirements, and the entire stakeholder community. The team will create processes and methods designed to influence behaviors necessary for successful program management.

The IMS is a representation of how the program leadership team expects to execute a program plan. The essential element in developing a useful schedule is engaging the program team throughout the development process. The IMS should always reflect reality and be owned by the entire program team if it is going to be effective. A well-constructed IMS reflects all of the contractual scope, is time phased, accounts for all required resources, and is based on sound engineering processes.

It is important to document and reiterate schedule and technical assumptions with the entire program team. Typically, this is done via a program kickoff meeting, an initial program review, subcontractor kickoff, or other similar programmatic events. This allows stakeholders to understand the IMS and its construction, aligning the entire program team with management approaches and measurements of success.

Once input is received from the Control Account Managers (CAMs) as to how their effort is represented in sequence and logically tied to effort outside of their efforts, the planner/scheduler calculates the schedule to determine if the original program goals remain achievable. If not achievable, the team determines the valid and executable changes necessary to meet goals. Changes can be any combination of the following: extending the period of performance, re-sequencing effort, changing a task calendar to allow more work hours per day or more work periods per week, applying additional resources to effectively shorten task durations, or possibly recommending scope removal. After constructing an executable IMS that meets the goals and expectations of the team and stakeholders, the team captures the IMS for performance measurement purposes by establishing the baseline.

During the execution phase of a program, frequent IMS updates and robust Quality Control (QC) processes are fundamental to a schedule's ability to accurately model the path forward. QC is a vitally important process as schedule output values are relied upon to coordinate efforts, communicate priorities, influence decisions, and develop risk mitigation plans. QC is challenging and should be performed by a team acutely familiar with the program direction and program contract requirements (refer to the Forecasting chapter in this guide for more details on schedule QC).

Review of schedule status inputs and subsequent schedule impacts is required by stakeholders at the lowest level of the organization. This provides status and impact validation prior to reporting schedule performance analysis up through the management chain. As the schedule is reviewed by each level of management, they should be given an opportunity to validate the results of the current schedule status. Senior management should ensure the schedule is consistent with efforts central to program direction and focus. The key for schedule quality control is aggressive program leadership that will drive the ownership, accountability, and discipline required to accurately model the road ahead.

It is vitally important that every activity in the schedule have correct logic, duration and align with resources. It's an unfortunate truth that it only takes one missing logic tie to change what was once thought to be the program direction. This is why it is so important that there is ownership and accountability for schedule data.

Example

Desirable Programmatic Conditions and Attributing Behaviors	
Condition	**Behavior**
Robust schedule management process	The schedule management process is documented and fully understood by all stakeholders. Any modification required to the schedule is clearly outlined in the program procedures. Managed changes can include; Baseline, Task Descriptions, Key Milestone Dates, Hand-offs, Deliverables, Logic, Duration, and Resources. Freeze periods should be understood and followed. The IMS is used as a basis for management and programmatic decisions.
Skilled planner/scheduler staff	The staff understands all aspects of schedule management and works with integrity and discipline in the development, management, and reporting of the schedule. They are proactive, motivated, and forward thinking in the anticipation of schedule issues that may potentially affect performance. Planner/Schedulers should be highly skilled and highly trained professionals with a sound working knowledge of engineering processes and the program life cycle. Planning/Scheduling IS NOT an administrative function.
Strong program office support and discipline	Program office fully supports the development and management of the schedule. It manages with the schedule, enforcing compliance and honesty in status and reporting. There is a collaborative management environment between the contractor and customer.
Ownership and accountability of schedule by all stakeholders	Stakeholders assume ownership of the IMS. The stakeholders understand their role and the importance of the schedule as it relates to program performance.
Documented information flow into and out of the schedule	Data used to status and report the schedule is well understood through program documentation. Subcontractor integration, manufacturing roll-ups, Government Furnished Equipment (GFE) are documented and easily identified within the schedule. Reporting of key dates, facility availability, contractual deliverables

Desirable Programmatic Conditions and Attributing Behaviors	
Condition	**Behavior**
	to various Functional areas, management, and customers are documented and identifiable in the schedule.
Understanding of schedule construction and terminology	All stakeholders have a clear understanding of schedule terms and architecture enabling effective communication of schedule goals and actions.
Well communicated goals in the form of key events/milestones	Events/Key Milestones are clearly communicated and visible to all stakeholders. They understand their role in the accomplishment of the program goals. Progress to these goals are measured and communicated as part of the regular report cycle.
Establish achievable plans and target dates	The IMS should reflect an achievable plan as denoted by baseline durations and dates. Additionally, the schedule should reflect realistic and accurate forecast dates, substantiated positive total float (work truly can be delayed without impacting goals), and substantiated negative total float (assumes this can be mitigated or else new target dates should be set).
Meaningful performance measurements	Metrics are geared to influence positive behaviors while identifying performance issues early. What is measured and managed strongly influences team direction and activity. Schedule variances are treated as opportunities for improvement instead of reasons for punishment.
Honesty and integrity in reporting by performers	Performers are empowered to status and report true progress and forecast to the schedule. Honesty in reporting is encouraged by program management allowing for accurate analysis of schedule issues.
Network forecast scheduling	The schedule is based on network logic, durations, constraints, and working calendars. A properly networked and statused schedule will quickly and accurately identify schedule problems and support accurate Estimate to Complete analysis.

Figure 3.1-1 Desirable Programmatic Conditions and Attributing Behaviors

Undesirable Programmatic Conditions and Attributing Behaviors	
Condition	**Behavior**
Lack of stakeholder involvement	Stakeholders underestimate the importance of the schedule or misunderstand their role as a participant.
Poor communication between relevant parties	Stakeholders/performers fail to communicate effectively. Schedule Integrity is jeopardized as roles and the accomplishment of team-based schedule goals are not fully understood. Schedule performance and forecasting of potential problems may be compromised as a result.

Undesirable Programmatic Conditions and Attributing Behaviors	
Condition	**Behavior**
Lack of management involvement driving accountability and ownership	Management fails to see the need for a schedule. Lack of support encourages performers to defer or ignore requests to plan and to maintain the schedule. Schedule becomes ineffective as a program management tool.
Unclear statement of requirements	Work lacks a documented definition. Delays in execution will result until requirements are fully documented and communicated.
Poor quality control	Sloppy planning, maintenance, or status of the schedule. A poorly constructed or maintained schedule provides inaccurate schedule data, crippling analysis and decision making by senior management.
Manipulation of schedule data to support political ends	Schedule dates dictated by management resulting in the schedule being used as a reporting tool only, lacking ability to forecast or anticipate problems.
Lack of experienced planner/scheduler support	Schedules are developed, statused, and reported by inexperienced staff. Proper schedule methods are not utilized. The schedule could become compromised by mechanical errors in network development, misuse of constraints or lags/leads, or lack of consistent and accurate status.
Lack of subcontractor integration	Vendor/Supplier schedules are not integrated effectively into IMS. Lack of relevant detail or integration results in an incomplete program picture and invalid schedule analysis.
Schedule built for reporting and not management	The schedule contains key dates but lacks a network model that represents planning assumptions by performers and provides no value in managing the program. Forecasting based on performance as well as critical path analysis is not possible.
Maintaining unachievable target dates	Maintaining target dates that are not achievable due to amount of remaining work to accomplish in remaining time left or targets that are now earlier than Time Now. This condition produces meaningless negative total float values that obscure management's ability to prioritize work and hinder effective program management.

Figure 3.1-2 Undesirable Programmatic Conditions and Attributing Behaviors

Optional Techniques

Refer to the "unconstrained CPM" method explained in the Critical and Driving Path Analysis chapter.

Things to Promote

The understanding that Time = Money and effective schedule management saves time.

Even though “critical path” is calculated by the scheduling tool, it should be fully vetted and accepted by the task owners and management team during each status cycle throughout the life of the program.

Think through and utilize a suite of schedule performance metrics that identify program objectives the results of which are fed back into the execution strategy. This will ensure you do not end up influencing behaviors that work counter to a schedules ability to model the future.

Clearly understand scheduling terms and their functions and uses (Total Float, Free Float, Start / Finish Variances, Late Start / Finish etc.). Use these values to instill the necessary behaviors needed to manage successfully.

Use a good schedule as a what-if analysis tool to show how even small changes can have a large impact on future performance.

Review and validation of the Critical Path by program leadership after each update is a staple of sound schedule management. This may include assessment of probabilistic critical paths where schedule risk on a path is considered likely to end up as the longest path when the effort has completed.

Recognize what the cultural necessities are to facilitate schedule utilization.

- Daily use
- Frequent (weekly / bi-weekly) update cycle
- Well thought out schedule management processes
- Highly skilled staff to maintain it
- Process discipline by all
- Program leadership
- Accountability and ownership for schedule data
- Well-designed information streams both in and out
- Executive / senior management participation and buy-in
- Understand how to use the schedule data
- Understand the terminology
- Clearly defined goals
- Incentives
- Quality planning throughout
- Questioning attitude… What-if
- Honesty
- Integrity
- Near term performance measurements
- Freeze period for the forecast modeling
- Confidence schedule data

Establish target dates on program milestones and program completion that produce meaningful total float values reflecting management’s approach to achieving program goals.

Establish a schedule baseline that reflects management’s execution plan, producing consequential performance metrics; update in an authorized and controlled manner when the plan is changed, supporting contractual dates.

Things to Avoid

At all cost, avoid the unenviable position of trying to defend a poorly constructed schedule. Realize that a poorly constructed schedule is a program management problem, and not a planner/scheduler problem. A poorly constructed schedule is a result, not a cause. Find the root cause. A schedule in this condition is due to poor schedule management practices and processes.   Recognize that a schedule cannot be “fixed” when there is an absence of stringent schedule management practices / process and where there is not ownership and accountability for schedule data. Address the cause, the schedule will improve.

Related Topics

Roles and Responsibilities of Program Personnel
Program Schedule Reviews
The IMS is a Tool not Just a Report
Critical and Driving Path Analysis

3.2 The IMS is a Tool, not Just a Report

Manager's View

The IMS is often required as a customer deliverable and sometimes viewed purely as a reporting instrument or a report only understood by a trained planner/schedule. This viewpoint misses the IMS effectiveness as the program's most powerful management tool. For the IMS to be an effective tool, it is necessary to have formal processes for the development, maintenance and daily management of the schedule. The IMS provides an ever-changing window into the progress (or lack of it) of current work effort. The strategic mission of a schedule is to point out future risks and opportunities. This provides the ability to mitigate future risks or capture potential opportunities that would have been otherwise unknown. Properly applied predictive schedule analysis is the key to achieving this mission. The role of Program Management is to ensure there is accountability for every aspect of this predictive schedule analysis.

Description

Schedule metrics, reports, and analyses provide a framework for the Program Team to understand both the current state of the work effort and assess the impact of today's status on work not yet accomplished. Status and comprehensive schedule analysis are required to provide the Program with a predictor of the plan going forward. Programs gain significantly from understanding IMS trends and risks. Programs will not realize the value of this performance feedback if it uses the IMS simply as a reporting tool.

Example

The following table (Figure 3.2-1) is a representative example of some key IMS analyses and metrics and summary of their value to management on programs that accurately maintain a program IMS.

IMS Analysis/Metric	Management Value
Critical/Driving Path Analysis	• Early identification of current and future critical and driving tasks that require management attention now • Provides a framework for proactive management of downstream risks • Quantifies the amount of time flexibility available to every program task
Schedule Risk Assessment (SRA)	• Predicts probability of program completion by date • Identifies tasks with a high probability of becoming critical • Helps to mathematically quantify program risk and opportunity • Paired with cost, provides probabilistic EAC data • Validates sufficiency of schedule margin duration (if applicable)
Critical Path Length Index (CPLI)	Measures how realistic the program completion date is and the efficiency rate required to complete the program as planned
Baseline Execution Index (BEI)	Reveals the "execution pace" for a program and provides an early warning of increased risk to on-time completion
Schedule Performance Index	Provides an early warning based on past performance to determine if the schedule is at risk and increased performance will be needed to complete on time

IMS Analysis/Metric	Management Value
Schedule Rate Charts	• Compares task completion rates to plan • Identifies forecast "bow waves"
Duration v. Scope Based %	Validates accuracy of in-process task finish dates
What-if Analysis	A comprehensive program model that can be used to model and assess alternative program execution strategies
Look Ahead Analysis	• Identifies activities scheduled to start in the near term • Quantifies the amount of time flexibility available to near term tasks
IMS Vertical Integration and Traceability	Ensures all program scope is accounted for in the program plans
Resource De-Confliction	• Identifies requirement conflicts and overlaps for key program resources (including people, places, and things) • Quantifies program staffing needs and validates realism for execution
Giver/Receiver - Hand-offs	Aids in communicating Hand-offs between program stakeholders
Monitoring Total Float to Program Milestones and Completion	• Diminishing positive total float may indicate a risk that the forecast schedule will not achieve program goals; requires management focus on activities contributing to schedule trends • Negative total float suggests that urgency and higher priority attention should be placed on root cause analysis and management actions to mitigate or else affected target dates must be changed to reflect / model reality • Modify program target goals to reflect achievable schedule, providing meaningful total float values to effectively manage to earliest completion; fully communicating these actions with customer involvement and concurrence
Monitor Finish Variance between Baseline and Forecast dates (threshold)	• Finish variance shows position against contractual commitments or internal targets • Monitor program milestone variances throughout the program • Monitor task variances exceeding established thresholds, paying special attention to any tasks that are on or approaching a critical or driving path • Combined with meaningful total float values provides powerful indicator to activities' lateness, earliness, and criticality
Monitor Start Variance between Baseline and Forecast dates (threshold)	• Use Start variances as leading indicators of work that is starting to slip, exceeding established threshold • Monitor task variances exceeding established thresholds, paying special attention to any tasks that are on or approaching a critical or driving path

IMS Analysis/Metric	Management Value
	• Combined with meaningful total float values provides powerful indicator to tasks' lateness, earliness, and criticality • Combined with Finish variance could assist in determining the realism of task durations

Figure 3.2-1 Key IMS Analyses and Metric Examples

Things to Promote

It is important that Planner/Schedulers assist the Program by displaying different views of schedule data for the user community to perform schedule analysis. The planner/schedule can periodically reproduce these views for assessment if the IMS contains consistent task coding.

It is also possible to perform 'what if' scenarios, by changing durations or relationships to see how the changes will affect your scheduled milestones.

Things to Avoid

Do not be a manager who only views the schedule as a report submission 'box to check'. This will result in missing the analysis and insight the IMS can provide. Schedule analysis provides actions, early warnings, process compliance feedback and an in-depth perspective to help in understanding impacts visible in other systems.

Related Topics

Managing using the IMS
Schedule Execution Metrics

3.3 Integration of Management Tools

Manager's View

The Integrated Master Schedule is the cornerstone document in the implementation of the Integrated Product and Process Development (IPPD) process. As such, it is essential that data in the IMS accurately reflect the quantifiable elements of the entire program plan. Additionally, programs should integrate the IMS with other management systems such as the Financial System, EVMS Cost System, Time Tracking System, Material Requirements Planning System, Risk and Opportunity Management, and Requirements Management Systems.

Description

On any program, the IMS is an essential, integrated element of the program's management approach. It is essential for the proper operation of the program that the data in the IMS be consistent with the overall program plan and integrated with the data in other business systems to maintain continuity across the program. Programs achieve integration of this data either manually or via automated systems. It is important to maintain this integration amongst the various systems to ensure that all participants on the program are making informed decisions based on a complete dataset. Inaccurate data integration increases the possibility of conflicting direction, potentially affecting the program.

The integration starts with the Systems Engineering Management Plan (SEMP) along with other functional plans that form the basis for all program planning. These plans describe the "who, what, where, and why" of the work that is to be accomplished, the IMS describes the when. Once developed, the IMS becomes a representative model of the technical work on the program and is the living document used to manage the execution of the program plans.

The IMS is not only a reflection of the functional plans, but also a reflection of the maturity of the design. Through the completion of the IMS tasks, the technical design maturity, as measured by the current state of the Technical Performance Measures (TPMs), reflects achievement of important interim program objectives. While typically not directly integrated in an automated sense, the IMS should be aligned and consistent with the program requirements and related tracking systems.

To provide for integration of cost and schedule, the IMS builds upon the technical information and aligns it with the structural and contractual elements such as the Work Breakdown Structure (WBS) and the Statement of Work (SOW). This information in the IMS provides the necessary traceability to the contract and forms the basis for the Earned Value Management System (EVMS) Performance Measurement Baseline (PMB).

Time-phased resources, including labor, applicable material and their associated budgets, captured in other business system tools should align and correlate to the tasking in the IMS. The labor resources assist in the bottoms-up reconciliation of staffing plans and are reconciled with company-level resource planning tools to provide the program team with an understanding of their consolidated resource needs and availability. The actual labor costs from the financial system are a crucial component of the EVMS.

Maintaining a direct correlation between the cost of a program activity and the duration is the basis of the earned value calculations and metrics. It is essential that the data in the schedule match the information in the EVMS cost system. For this reason, automation is the desired approach. In any event, maintaining a consistent and disciplined configuration control process will ensure accuracy in the earned value data used to manage the program and provided to the customer.

Because the IMS is the focus document for the entire program team, the program should capture all activities on the program in the schedule. The program typically manages risk mitigation and opportunity capture plans in a separate Risk and Opportunity (R&O) tool, which provides the program with the necessary data to report, monitor, track, and assess R&O impacts. The program should ensure the integration of R&O in the IMS, regardless of duplicity.

Note: The reason for the separate R&O database is so that candidate risks and opportunities and accepted risks/opportunities can be managed prior to the authorized inclusion of the mitigation or capture tasking in the program IMS and Performance Measurement Baseline (PMB).

The final system requiring integration with the IMS is the Material Requirements Planning (MRP) system. The production factory typically utilizes a very detailed management systems to monitor and track all the items necessary (Bill of Material (BOM)) to build the final product(s) using Standard Times for individual task execution, with standard lead times for material procurement based on material commodity classification. This can run into the thousands of separate tasks and is too complex to manage in an IMS. Therefore, programs should integrate the data from the MRP system at a higher level than other tasking in the IMS. This can be accomplished by potentially using higher level/longer duration tasks that summarize detailed MRP tasking, to ensure that the contract IMS status reflects the status of the manufacturing progress in the MRP/ERP system. This level of visibility in the IMS is sufficient to manage the overall program, while managing the details on the factory floor. Programs should take care to ensure that the summary build durations capture overall standard times for the MRP activity. Additionally, programs should ensure to translate material lead-times to appropriate accrual or voucher timeframes in support of EVM requirements.

Examples

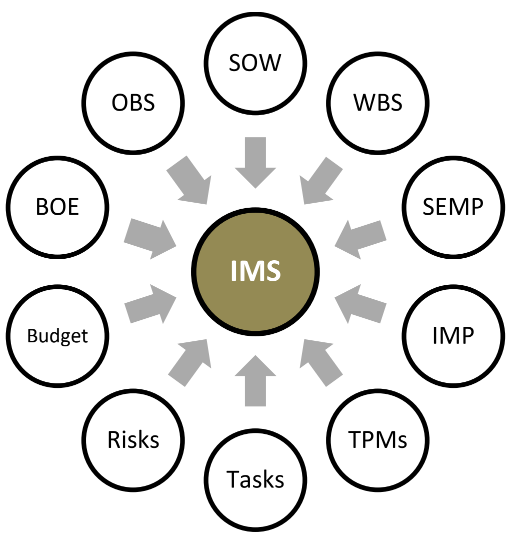


Figure 3.3-1 IMS Planning Inputs

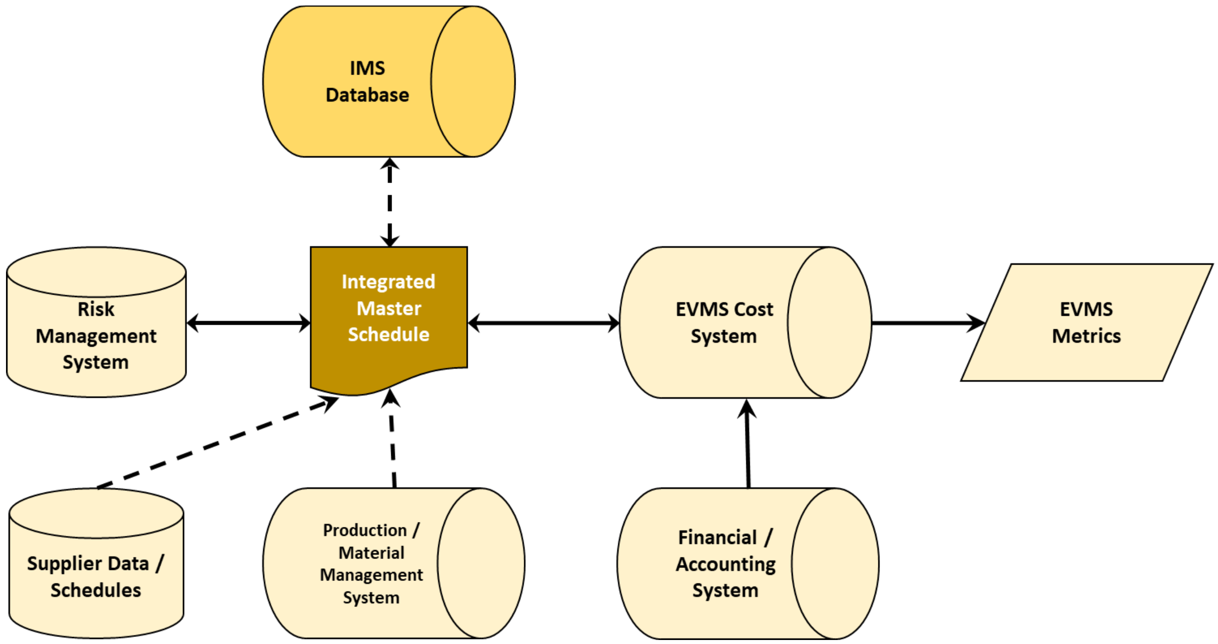


Figure 3.3-2 IMS Tool Integration

Things to Promote

Ensure a detailed understanding and direct involvement by the PM, Chief Engineer, and CAMs in the IMS development, status, maintenance, and analysis.

Ensure the IMS contains all contractual requirements, risk mitigation and opportunity capture plans, key material receipts, key subcontractor efforts, and make/buy decisions.

Ensure the program derives its resource requirements and staffing plan from the IMS.

Ensure the program can trace SOW paragraphs, WBS elements, and Technical Requirements Documents (TRDs) to IMS activities.

Ensure the program maintains traceability of the history relating to changes in the IMS. This validates the program change logs, ensuring approval of all changes before incorporation and ensuring that unapproved changes do not reside in the IMS.

Things to Avoid

Avoid losing configuration control of the IMS as it could result in a situation where the IMS does not reflect the program's execution strategy.

Making changes in one business system without making a corresponding change in the IMS, or vice versa.

Avoid the belief that implementing complex IT systems, with automated systems and sub-systems, is a valid replacement for sound management processes (i.e., managing to a well-constructed IMS). In general, it is far more beneficial to have effective processes in place than to attempt to automate poorly designed processes.

Related Topics

Horizontal Traceability
Vertical Integration and Traceability
Managing using the IMS

3.4 Roles and Responsibilities of Program Personnel

Manager's View

There are a number of key roles in the management and execution of a schedule. Understanding these roles and responsibilities provides the program team with the expectations, responsibilities, and accountability necessary for successful program execution.

Program teams are comprised of functional, program, and/or matrix personnel. Understand that the program team and ultimately the program manager are responsible for the schedule, not the planner/scheduler. All members of the program team form an integral partnership in developing the baseline, maintaining, analyzing, and reporting progress and future projections. The program team operates in a timely fashion to ensure the IMS management process leads to successful program execution.

Description

The size of a program team depends on the size of their program. Large programs generally consist of a Program Manager, Integrated Product Team (IPT) Leads, Control Account Managers, Schedulers/Planners, Business Finance, Subcontractors, Functional Managers, and the Customer. On smaller jobs, programs often consolidate these roles.

Program Manager

The Program Manager (PM) is ultimately responsible and accountable for ensuring the successful completion of a program. As part of managing the program team, the PM needs to have a solid understanding of team roles and the planning process.

The PM energizes team members to establish and maintain a consolidated schedule to meet program needs and objectives. Program personnel are responsible and accountable for executing the schedule. The PM oversees the execution and maintenance of the schedule, and aggressively drives a sense of ownership and accountability for the schedule and its supporting processes (see Managing Using the IMS)

PM planning activities include:

1. Confirming that the IMS is accurate and developed at a level enabling IPT management of their product and sub-product efforts
2. Ensuring that the IMS structure addresses external and internal programmatic and product requirements and that program elements are integrated.
3. Ensuring the early involvement of all functional elements when generating a program schedule
4. Understanding that schedule fidelity needs to be tailored based on the maturity / phase of the program, and the availability of related planning systems
5. Understanding that building / maintaining schedules can be very challenging and complex, and that the right team / skills need to be in place
6. Understanding key scheduling terms
7. Understanding the difference between tasks that are considered "crucial" or "critical" to the program and tasks calculated as "Critical" by the scheduling software.
8. Understanding how Critical Path/Float analyses are used to crash critical paths and guide the assignment of resources
9. Promoting schedule quality and integrity
10. Promoting the idea that sound planning is an investment in time and energy, resulting in a benefit and not a cost.
11. Providing oversight and review of schedule execution

12. Hold program personnel accountable for execution to the schedule
13. Use schedule analysis to pro-actively manage program issues, risks, and opportunities

Integrated Product Team (IPT) Lead

IPT Leads are usually the next level of management below the Program Manager (PM). To ensure successful completion of a program and as part of the management team, IPT Leads flow PM responsibilities and accountabilities down to their personnel. Like the PM, IPT Leads need to have a solid understanding of team roles and the planning process.

IPT Leads energize program personnel to establish and maintain a consolidated schedule to meet program needs and objectives. Program personnel are responsible and accountable for executing the schedule. The IPT Lead oversees the execution and maintenance of the schedule, and aggressively drives a sense of ownership and accountability for the schedule and its supporting processes. IPT leads also facilitate communication between different levels of the program organization.

IPT Leads may also facilitate negotiations between CAMs in re-allocation of time, work with functional management to resolve resource issues, and work with their counterparts in the Customer Program Office in clarification of requirements and customer direction.

IPT Lead planning activities are identical to those of the PM, tailored to the scope of the IPT.

Control Account Manager

A Control Account Manager is responsible for the technical, schedule, and budget related management of a specifically defined element of scope within the contract. Control Account Managers (CAMs) are responsible for ensuring the accomplishment of the scope of work in his or her control accounts and are the focal points for management control. CAMs determine how their respective effort is represented in the IMS (sequence, logic, durations, etc.) and are responsible for establishing and managing their portion of the baseline. Typically, CAMs report to an IPT Lead. On larger programs, CAMs may delegate specific roles to Work Package Managers (WPMs), if they remain cognizant and responsible for the entire control account.

As CAMs are responsible for the detail plans, they need to have an extensive knowledge of the team roles and planning process. To ensure successful completion of a program and as part of the program team, CAMs/WPMs flow PM responsibilities and accountabilities down to their personnel.

CAM/WPM planning activities include those of the PM but also include the following:

- Developing the baseline including relationships, duration, and interfaces. The CAM ensures the baseline is achievable and meaningful.
- Performing status, analysis and baseline maintenance of the IMS tasking within their Control Accounts.
- Accepting the responsibility for the validation of the tasking, including the definition of relationships, durations, assignment of task earned value techniques, % complete determination, and resource distribution and de-confliction of the tasking within their Control Accounts.
- Accepting responsibility for ownership of all aspects of the IMS tasking within their Control Accounts.

Planner/Scheduler

The development and maintenance of a schedule can be very challenging and complex. It is important that scheduling personnel have the appropriate background and skill set (see the Training Section for specifics on planner/scheduler training). A group of planner/schedulers, under a planning/scheduling lead, typically supports larger programs. Planner/Schedulers need to have a thorough understanding of scheduling terms, processes, and tools.

Planner/Schedulers are responsible for ensuring the PMs and CAMs adhere to an effective schedule construction, maintenance, and analysis process. They translate the program team's vision of the workflow by modeling it in a scheduling tool. They ensure the IMS contains all discrete program activities; balance schedule fidelity based on the program needs and interfaces with other systems and ensures schedule integrity using metrics and other schedule health indicators.

Specifically, planner/schedulers need to:

- Drive the program's technical approach into the IMS through a strong understanding of the System Engineering life cycle.
- Promote the idea that good planning is in itself a goal, and that it is a benefit instead of a cost
- Work with the team to identify all discrete efforts, task dependencies, and resource constraints.
- Establish and maintain a quality schedule that adheres to appropriate standards including task naming, coding, and reporting
- Understand and implement sound EVM processes into the schedule management process
- Assess the health of the schedule using metrics and/or incorporate accurate task/milestone progress to drive IMS improvements
- Should ensure horizontal and vertical integration of the schedule
- Maintain a controlled IMS baseline and forecast
- Ensure continuous involvement of all functional elements when generating a program IMS
- Aggressively drive a sense of ownership and accountability for schedule data and supporting processes
- Support the program team and those responsible/accountable for execution of the schedule
- Understand key scheduling terms and processes
- Understand the difference between tasks that are considered "crucial" or "critical" to the program and tasks calculated as "Critical" by the scheduling software. Understand how to use Critical Path/Float analyses to optimize program resources and implement mitigation strategies through what-if modeling
- Use the Schedule Risk Assessments (SRAs) process to gather three-point estimates, determine risk-critical activities, and to pro-actively manage risk-critical activities
- Use the schedule as a management and communications tool

Finance Analyst

As a central planning document, programs integrate the schedule with the program resources and costs to facilitate program management functions. This can be done within the schedule itself (a resource loaded IMS), or within the finance systems.

Specifically, a Finance Analyst needs to:

- Validate that the assigned resources and associated time phasing works within program budget and funding constraints
- Assess schedule health using metrics and/or other indicators as they relate to cost
- Assist in preparing Schedule/Finance integrated reports

Subcontractors

Subcontractors may have contractual requirements to generate and maintain an IMS for their effort. Working with the prime contractor, it is crucial that key hand-offs, product deliveries, and other coordination activities be accounted for in both schedules. These interface points become important to management and control points within the entire program plan. Additionally, subcontractors coordinate the delivery schedule and format of IMS data with the prime contractor (See the Subprojects/External Schedule Integration chapter for more information)

Alternatively, the subcontractor may develop a schedule within the Program IMS and provide baseline maintenance and status updates during each cycle.

Functional Managers

Because the functional organizations typically supply the program team with IPT leads, CAMs, and individual contributors, it is important for the functional managers to have a solid understanding of program planning and management approaches so that they can assess the performance of their personnel. The functional manager is responsible for providing the resources needed by the program to meet program commitments as time phased in the IMS. Additionally, the functional manager will validate that the IMS tasking within their functional area is achievable.

Executive Manager

Typically, "matrix" functional organizations staff program needs, an Executive Manager is required to align the goals and resources of the company with program needs and commitments. The Executive manager comes from upper level management in the form of a company Vice President or Director. This individual possesses the authority to enforce contractual commitments on behalf of the company and program. Organizationally the Program Manager reports directly to an Executive manager, who manages a portfolio of related programs.

Things to Promote

Ultimately, the program manager, and not the planner/scheduler, owns the program IMS. Program Managers should accept this responsibility and ensure that the IMS accurately reflects the programs execution strategy and uses it as an effective predictive model.

Ensure all program stakeholders are versed in IMS-specific "language" and terms to facilitate effective communication on the IMS.

Things to Avoid

Avoid focusing solely on the minute schedule details or intricacies of scheduling software and thereby losing perspective of the big picture of what the team is trying to accomplish.

Related Topics

Managing using the IMS
Subprojects/External Schedule Integration
Resources in the Schedule
Resources Not in the Schedule

4 Schedule Architecture

This section contains the following chapters.

4.1 IMS Architecture

Manager's View

Schedule Architecture is the organizational structure of the work scope or tasks within a program's Integrated Master Schedule (IMS). The most common IMS architectures are the event-based IMP architecture and the product based WBS architecture. The Program team should determine the schedule architecture prior to creating the IMS.

Description

An **Integrated Master Plan (IMP)** is an Event-based plan with sufficient definition to allow for tracking progress toward completion of a program. An IMP structure subdivides Events into required Significant Accomplishments for the Event and Completion Criteria for each Significant Accomplishment. An IMS with an IMP-driven Architecture incorporates the IMP events, accomplishments, and criteria into its framework. Add detailed tasks to depict the steps required to satisfy criterion. An IMP-based IMS focuses attention on completing the tasks satisfying the entrance and exit criteria for the events and assessing progress towards completing those events.

A **Work Breakdown Structure (WBS)** is an organized method to break down and define the products into sub-products, each at lower levels of detail. It is a product-oriented family tree composed of hardware, software, services, data, and facilities. Structure for an IMS with a Product/WBS Architecture focuses on the products which is different from the event-centric structure of the Event/IMP architecture. With a Product/WBS structure, detailed tasks depict the steps required to complete the products. Thus, a WBS-based IMS focuses attention and assesses progress towards completing those products. Often programs with EVMS requirements will be required to apply the MIL-STD-881C for Work Breakdown Structures. It is important to keep compliance to the Standard in mind when selecting WBS levels and names for Control Accounts and Work Packages in the IMS (when applicable).

Examples

The following example (Figure4.1-1) shows an excerpt of an Integrated Master Plan (IMP).

IMP Level	IMP ID	Task Name
Event	5.0	⊟ Internal Integration & Pre-Qual Test Complete
Accomplishment	5.1	⊟ GNC Software Builds Complete
Criteria	5.1.1	⊞ GNC Software Build 1 Complete
Criteria	5.1.2	⊞ GNC Software Build 2 Complete
Criteria	5.1.3	⊞ GNC Software Build 3 Complete

Figure 4.1-1 Excerpt of an Integrated Master Plan (IMP)

The following example (Figure 4.1-2) shows detailed tasking structured based on the IMP architecture.

IMP Level	IMP ID	Task Name	WBS#
Event	**5**	**Internal Integration & Pre-Qual Test Complete**	
Accomplishment	**5.1**	**GNC Software Builds Complete**	
Criteria	**5.1.1**	**GNC Software Build 1**	
Task	5.1.1	Determine GNC SW Build 1 Requirements	1.1.6.5a
Task	5.1.1	Conduct GNC SW Build 1 Design	1.1.6.5a
Task	5.1.1	Code GNC SW Build 1	1.1.6.5a
Task	5.1.1	Conduct GNC SW Build 1 Unit Test	1.1.6.5a
Criteria	**5.1.2**	**GNC Software Build 2**	
Task	5.1.2	Determine GNC SW Build 2 Requirements	1.1.6.5b
Task	5.1.2	Conduct GNC SW Build 2 Design	1.1.6.5b
Task	5.1.2	Code GNC SW Build 2	1.1.6.5b
Task	5.1.2	Conduct GNC SW Build 2 Unit Test	1.1.6.5b
Criteria	**5.1.3**	**GNC Software Build 3**	
Task	5.1.3	Determine GNC SW Build 3 Requirements	1.1.6.5c
Task	5.1.3	Conduct GNC SW Build 3 Design	1.1.6.5c
Task	5.1.3	Code GNC SW Build 3	1.1.6.5c
Task	5.1.3	Conduct GNC SW Build 3 Unit Test	1.1.6.5c

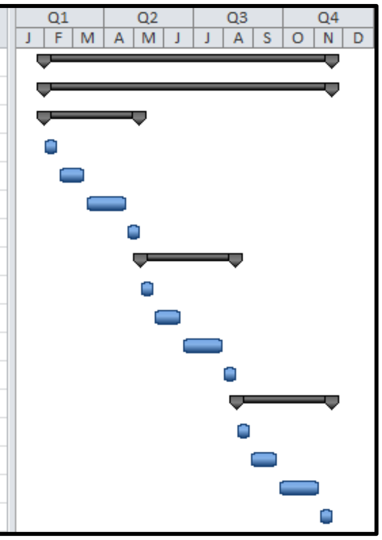


Figure 4.1-2 Example of a detailed schedule based on an IMP Structure

The following example (Figure 4.1-3) is an excerpt of a Work Breakdown Structure (WBS).

WBS#	Task Name
1.0	**Weapon System**
1.1	**Air Vehicle**
1.1.6	**Guidance & Control Equipment**
1.1.6.5	**GNC Application Software**

Figure 4.1-3 WBS excerpt

The following example (Figure 4.1-4) shows detailed tasking structure based on the WBS architecture.

WBS#	Task Name
1	**Weapon System**
1.1	**Air Vehicle**
1.1.6	**Guidance & Control Equipment**
1.1.6.5	**GNC Application Software**
1.1.6.5a	**GNC Software Build 1**
1.1.6.5a	Determine GNC SW Build 1 Requirements
1.1.6.5a	Conduct GNC SW Build 1 Design
1.1.6.5a	Code GNC SW Build 1
1.1.6.5a	Conduct GNC SW Build 1 Unit Test
1.1.6.5b	**GNC Software Build 2**
1.1.6.5b	Determine GNC SW Build 2 Requirements
1.1.6.5b	Conduct GNC SW Build 2 Design
1.1.6.5b	Code GNC SW Build 2
1.1.6.5b	Conduct GNC SW Build 2 Unit Test
1.1.6.5c	**GNC Software Build 3**
1.1.6.5c	Determine GNC SW Build 3 Requirements
1.1.6.5c	Conduct GNC SW Build 3 Design
1.1.6.5c	Code GNC SW Build 3
1.1.6.5c	Conduct GNC SW Build 3 Unit Test

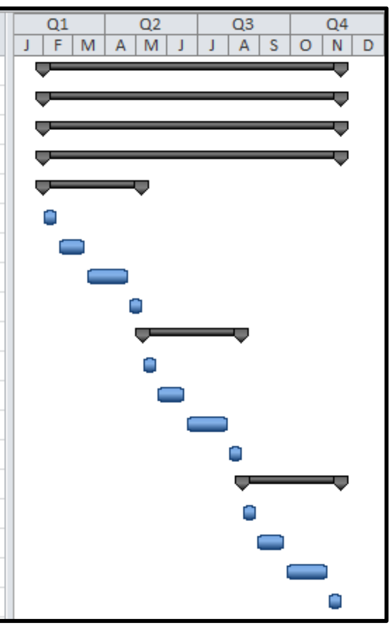


Figure 4.1-4 Detailed tasking structure based on the WBS architecture

Note: The WBS and IMP structure will not always follow each other one-to-one as depicted in these examples.

Optional Techniques

All major scheduling tools have options to group, sort, or filter the IMS based on data resident in coding fields. Therefore, assuming the code fields are accurately populated, programs can create IMS views that depict, for example, the IMS sorted by WBS even if the IMS outline is structured based on the IMP.

Include a resolution of action items from the previous event as entrance criteria to the succeeding event.

Note: In some circumstances the nature of the product being built or developed may necessitate the use of a different WBS (i.e. Shipbuilding).

Things to Promote

An Event/IMP Architecture promotes a more thorough planning process and emphasizes the time domain while one with a Product/WBS Architecture is more suited to the cost domain. Programs should architect the IMS to allow for multiple hierarchical structures or roll-ups. Examples include IMP, WBS, OBS, IPT, PBS, or Control Account etc.

Ensure that the IMS tasks are traceable to the IMP events that they support (i.e. tie tasks that supports CDR to CDR Criteria).

Ensure that each lowest level architectural element is supported by a least one IMS task and that each IMS task supports a lowest level architectural element.

If the program has a requirement to use both an internal WBS and a customer directed WBS, then it is recommended that both be resident within the IMS (in separate coding fields) and required that both be traceable to the IMS.

Use the simplest method in the IMS to capture WBS coding, which may or may not be via the software tools native WBS field.

Regardless of the primary architecture used, ensure the IMS is structured in a way that encompasses the entire scope of discrete work.

Things to Avoid

Adding tasks in the IMS to represent IMP Accomplishments and Criteria is not a substitute for using a coding structure to accomplish the architecture.

Related Topics

Integrated Master Plan (IMP)
Vertical Integration and Traceability
Horizontal Traceability
Top-Down v. Bottom-Up Planning

4.2 Integrated Master Plan (IMP)

Manager's View

An **Integrated Master Plan (IMP)** is an event-based plan that demonstrates maturation of a product as it progresses through a program's life cycle. It represents the top-level execution strategy for the program and often serves as the primary architecture or outline of the IMS. Although the Events appear in sequential order, the plan demonstrates the execution approach without being time related. Done correctly and prior to the development of the IMS, an IMP adds rigor and integrity to the program planning process, helps to reduce execution risk, and results in a more robust IMS. In some cases, an IMP is contractually required; though even when not required, it is a disciplined and comprehensive way to plan a program. Many companies have adopted the IMP as part of their standard planning process.

Note: In some cases, acquisition professionals use the term IMP in reference to only an IMP Matrix/Product Section (i.e. Events, Accomplishments, and Criteria). In other cases, they use the term in reference to a larger document that contains several sections, including:

- An introduction describing the IMP
- An IMP Matrix/Product section
- A Narrative section
- A glossary

This chapter focuses primarily on the IMP Matrix/Product section.

Description

Definition

The IMP Matrix is a hierarchy of:

- Level 1 - program-selected **Events**
- Level 2 - Significant **Accomplishments** (SAs) required to complete the Event
- Level 3 - Accomplishment **Criteria** (AC) that demonstrate completion of the Accomplishment

The elements of the IMP Matrix are not constrained by calendar dates. Each Event is complete when its Accomplishments are complete. Each Accomplishment is complete when its Criteria are complete. The format for an IMP can be a list, spreadsheet table, or narrative document or any combination of the three. It may also define the entrance and exit criteria. Typically, Accomplishment and Criteria level descriptions use past tense verbs to describe clearly the element's completed scope.

Application

You can use an IMP Matrix on any program and in any phase of an acquisition, modification, or sustainment effort. Use of the IMP Matrix is independent of the program's complexity, size, or cost. However, these factors may affect the necessary level of detail.

An IMP Matrix is most effective when developed in collaboration with the entire program team and early in the planning process. The IMP evolves iteratively, over the course of the planning process, and if there are scope changes, updated during program execution following configuration control processes and customer submittal and approval where required.

Purpose

The IMP Matrix helps to define and communicate the program's approach to meeting its objectives and contractual requirements. Often, it also serves as the primary architecture and foundation for the program's Integrated Master Schedule.

Steps in the IMP Development

1. Determine if the program needs only an IMP Matrix or a full IMP (i.e. Introduction, IMP Matrix, Narrative, and Glossary)
2. Build the IMP Matrix
    a. Identify Events, Accomplishments, and Criteria
    b. Validate that the program requirements (i.e. SOW) are covered within the IMP Matrix
    c. Assign a hierarchical number system, ensuring all Events, Accomplishments, and Criteria have a unique identifier
    d. Ensure each Criteria supports a single Accomplishment, and each Accomplishment supports a single Event
3. If applicable, write Introduction Section
4. If applicable, write Narrative Section
5. If applicable, write Glossary Section.
6. Continuously review and update the IMP throughout the IMS development and execution (with customer concurrence as applicable).

Attributes of IMP Sections

Consider including the following attributes (as appropriate based on the individual program needs) in the IMP sections:

Introduction

- Program overview and management approach to executing the program
- Explanation of the IMP Matrix numbering and cross-referencing conventions
- Key assumptions and ground rules
- Program team structure and responsibility

IMP Matrix / Product Section

- Level 1 - Events
    - Represent maturation phases that often conclude with a program milestone
    - Are appropriate points to assess the program's progress
    - Are sequential for planned execution order but may overlap
    - May be customer-directed
    - May encompass phases such as program design reviews, tests, deliveries, and other key progress demonstration or risk mitigation points
    - Do not have dates
    - Number around 2 – 4 per year (based on program needs)
    - Include an Event description that defines the purpose and objective of each Event
- Level 2 - Accomplishments
    - Represent major steps required to complete the supported Event
    - May represent completion of internal milestones

- Number at least 2 per Event (based on program needs)
- Level 3 - Criteria
  - Are measurable indicators
  - Represent definitive evidence that the Accomplishment it supports is complete
  - Number at least two per Accomplishment

Narrative Section

- Explains special and crucial tasks or processes to provide additional insight to stakeholders
- Provides additional information not covered in the other three sections.

Glossary

Contains terms, action verbs definitions, and acronyms used in the IMP

IMP Relationship to the IMS

It is important to establish and maintain a direct correlation between the IMP and the IMS. There are two common methods used for creating the IMP to IMS correlation:

1. Use the IMP Matrix as the primary architecture / structure of the IMS. This means that the IMP Matrix is the top three levels (Event, Accomplishment, Criteria) of the IMS and the detailed tasking below the criteria represents a further breakdown of the scheduled work. Additionally, the unique IMP number system is flowed down to the discrete tasks and maintained in the IMS in field defined by the user.
2. Use the WBS or other structure as the primary architecture of the IMS and then map the detailed tasks and milestones (as applicable) to the IMP Matrix via a unique IMP numbering system in a field defined by the user.

Examples

The following figure (Figure 4.2-1) shows one format for an IMP Matrix.

IMP Level	IMP ID	Task Name
Event	5.0	⊟ Internal Integration & Pre-Qual Test Complete
Accomplishment	5.1	⊟ GNC Software Builds Complete
Criteria	5.1.1	⊞ GNC Software Build 1 Complete
Criteria	5.1.2	⊞ GNC Software Build 2 Complete
Criteria	5.1.3	⊞ GNC Software Build 3 Complete

Figure 4.2-1 IMP Product Section Example #2

The following figure (Figure 4.2-2) shows that same IMP Matrix as the architecture of the IMS.

IMP Level	IMP ID	Task Name	WBS#
Event	**5**	**Internal Integration & Pre-Qual Test Complete**	
Accomplishment	**5.1**	**GNC Software Builds Complete**	
Criteria	**5.1.1**	**GNC Software Build 1**	
Task	5.1.1	Determine GNC SW Build 1 Requirements	1.1.6.5a
Task	5.1.1	Conduct GNC SW Build 1 Design	1.1.6.5a
Task	5.1.1	Code GNC SW Build 1	1.1.6.5a
Task	5.1.1	Conduct GNC SW Build 1 Unit Test	1.1.6.5a
Criteria	**5.1.2**	**GNC Software Build 2**	
Task	5.1.2	Determine GNC SW Build 2 Requirements	1.1.6.5b
Task	5.1.2	Conduct GNC SW Build 2 Design	1.1.6.5b
Task	5.1.2	Code GNC SW Build 2	1.1.6.5b
Task	5.1.2	Conduct GNC SW Build 2 Unit Test	1.1.6.5b
Criteria	**5.1.3**	**GNC Software Build 3**	
Task	5.1.3	Determine GNC SW Build 3 Requirements	1.1.6.5c
Task	5.1.3	Conduct GNC SW Build 3 Design	1.1.6.5c
Task	5.1.3	Code GNC SW Build 3	1.1.6.5c
Task	5.1.3	Conduct GNC SW Build 3 Unit Test	1.1.6.5c

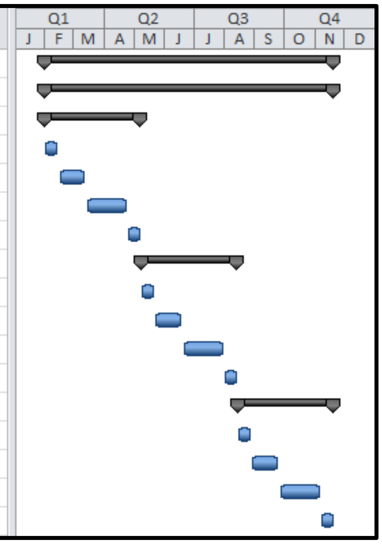


Figure 4.2-2 IMS using an IMP as the Architecture

The following figure (Figure 4.2-3) shows several Event Description examples.

EVENT	DEFINITION
Post-Award Conference (PAC) Completed	The purpose of this event is to ensure that the contractor's management processes and tools have been implemented and that both the Government/contractor have a common understanding of the program to be executed. The IMP Accomplishments and Criteria and overall schedule will be reviewed, as well as risk status and program metrics. The PAC Event represents the transition from initial post-contract award process implementation and planning updates to a major block of activity related to…
Critical Design Review (CDR) Completed	The purpose of this event is to ensure that the detail design is essentially complete. It will (1) determine that the detail design under review satisfies the performance and engineering requirements; (2) establish the detail design consistency; (3) assess risk areas (on a technical, cost, and schedule basis); and (4) finalize the preliminary item specifications for the subsystems.
Functional/ Physical Configuration Audit (FCA/PCA) Completed	The purpose of this Event is to ensure that the contractor has established a baseline design and physical configuration that meets the performance requirements of the program. It includes validation that the development of a configuration item has been completed satisfactorily and that the configuration item has achieved the performance and functional characteristics specified in the functional or allocated configuration identification. It also includes a technical examination of designated configuration items to verify that the configuration item "As Built" conforms to the technical documentation which defines the configuration.

Figure 4.2-3 Example of Event Dictionary Elements

This figure (Figure 4.2-4) shows how an IMP Code (numbering structure) can be viewed in the IMS.

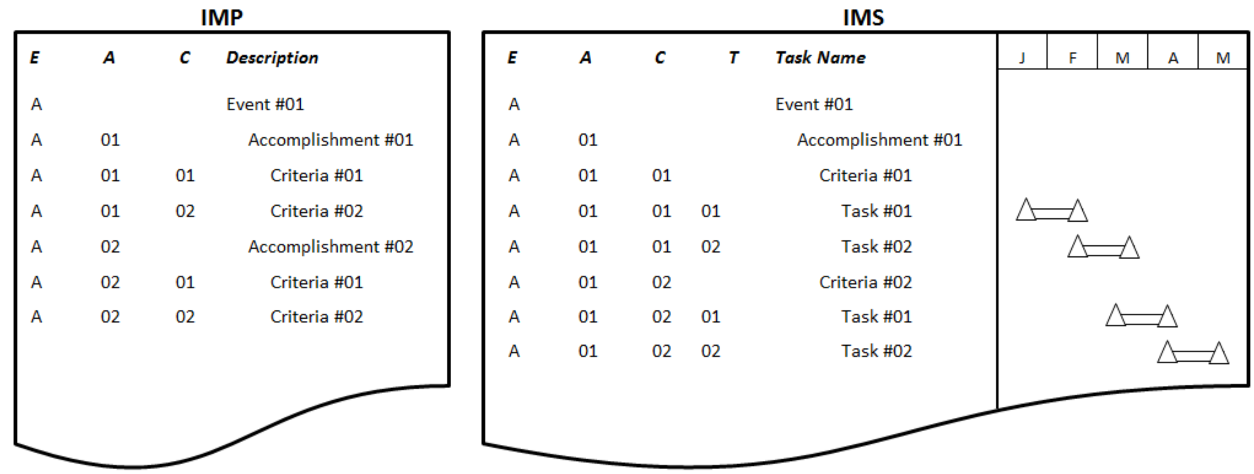


Figure 4.2-4 Example IMP Code (numbering structure)

The following is an example of a Glossary (Figure 4.2-5).

Example IMP Terms and Definitions	
Allocated	Apportioned to specific elements. Implies that supporting documentation exists.
Appointed	Selection process has been completed and individual alerted. Should be in place within 15 days.
Analyzed	Technical evaluation completed using equations, reduced data, etc.
Assembled	Pieces brought together forming a larger element.
Available	Item in question is in plan and operational or ready for use.
Cleared	Action items have been satisfactorily resolved and noted as such.
Completed	The item has been prepared, reviewed, signed off as required, and is available for use.

Figure 4.2-5. Example Glossary

Exhibit

The following graph (Figure 4.2-6) depicts the Top-Down, Bottom-up Methodology.

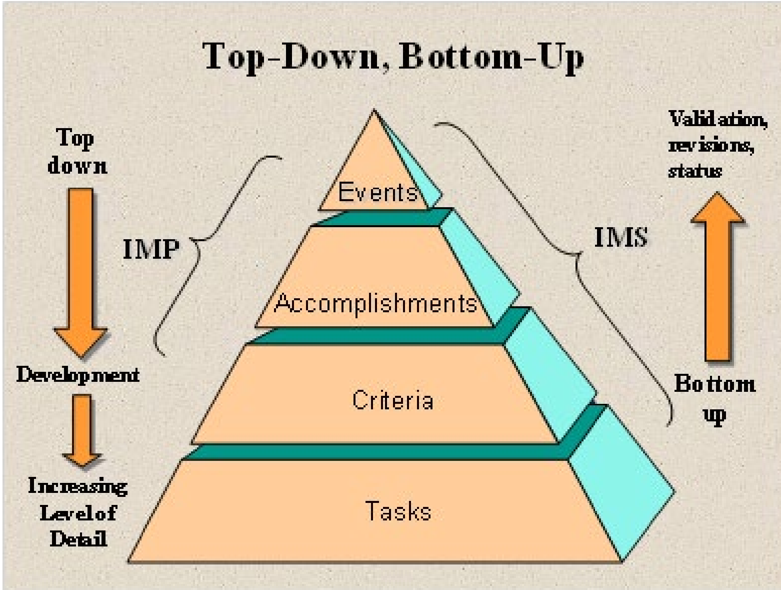


Figure 4.2-6 Top-Down, Bottom-up Methodology

Things to Promote

Consider creating an IMP Matrix even if the program is not planning to use it as the primary architecture of the IMS. The IMP creation process enhances the program personnel's understanding of the program before diving into the details and affords the opportunity to validate the program's scope and execution approach.

Consider including risk mitigation techniques (i.e. prototyping, early testing, build sequences, trade studies) in the IMP to help to communicate how the program addresses major risks.

Understand that while it is important to have the correct Events and Accomplishment, there is no single solution that works for all programs (i.e. Events for one program might be Accomplishments for another).

Ensure that the IMP Matrix correlates with and is traceable to both the WBS and the SOW. There may be more than one SOW or WBS element associated with a single IMP element.

Incorporate an IMP Matrix unique numbering scheme that allows mapping of IMP elements in the IMS, whether using the IMP Matrix as the IMS structure or not.

Use Criteria identifying products that the program develops rather than the functions or activities that it performs. Criteria should answer the question "How do you know you're done?"

Keep the IMP under configuration control once it is established and approved. (Note: may require customer approval as defined in the CDRL.)

When breaking IMP elements into lower level elements ask: "What are the 2-4 most important segments of this element?" Then, as a validity check, ensure they are at an equivalent level and adjust as necessary.

Use clear, meaningful IMP element descriptions at all levels that include past tense verbs (on Accomplishments and Criteria) to denote the emphasis on completion.

Ensure the IMP creation process is a collaborative effort with inputs from all program teams.

Ensure program teams accept and understand the event, accomplishment, and criteria ownership.

Ensure that verbs are consistently used and defined in the Dictionary.

Maintain the IMP after the program begins execution. It forms a common communication bond between the contractor and the customer and is an excellent tool for understanding current program maturity.

Ensure Vertical Integration and Traceability between a task, through its associated Criteria and Accomplishment, to the Event is consistent with the workflow resulting in Event completion.

Consider including the resolution of actions items from a preceding Event to the entrance criteria of the succeeding Event.

Things to Avoid

Avoid "backing into" the IMP after the IMS has been created. The program loses the top-down planning benefit provided by the IMP development process.

Avoid attempting to apply dates to IMP elements during IMP development. The IMS establishes all dates.

Avoid attempting to define dependencies between IMP items. The IMS establishes dependencies.

Watch out for one-to-one relationships in the IMP (i.e. only one Criteria for an Accomplishment). This is typically an indicator that level of detail in the IMP is too low and that you should consider consolidating elements to a higher level.

In order to minimize rework, avoid starting IMP development until the technical approach, WBS, and SOW are relatively stable.

Avoid making the IMP too detailed, as this can drive too much detail into the IMS and may inhibit program flexibility (as many IMPs are contractual).

Avoid unclear descriptions and definitions of the IMP elements, as they will lead to uncertainty and confusion.

Related Topics

IMS Architecture
Schedule Hierarchy
Top-Down v. Bottom-Up Planning
Vertical Integration and Traceability

4.3 Schedule Hierarchy

Manager's View

In order to facilitate the needs of many stakeholders, programs maintain multiple levels of schedule hierarchy. Program teams define the information at each level to aid in the use of the schedules as an effective and efficient communication vehicle. The dates between each level of the schedule hierarchy should be vertically traceable but do not necessarily need to reside in the same "file" or tool.

Schedule Hierarchy is as follows:

- Level 1 – Summary Master Schedules
- Level 2 – Intermediate Schedules
- Level 3 – Detailed Schedules

It is important to understand that all levels of schedule hierarchy come from one data source, the detailed IMS. The Summary Master and Intermediate level schedules are simply summarized roll-ups of that detailed IMS.

Description

Summary Master Schedule

The Summary Master Schedule is ideally a one (1)-page schedule and may also be called a Master Phasing Schedule (MPS), Master Plan or Summary Schedule. As the highest, least detailed schedule, the program's summary master schedule highlights the contract period of performance, program milestones, and other significant, measurable program events and phases.

The Program Team initially develops the program summary master schedule from the analysis of requirements data during the pre-proposal phase and similar past program efforts. The program team review and approve the program's top-level schedule, which serves as a starting point in the Top-Down planning approach (See Top-Down v. Bottom-up Planning). This process continues until contract award to include any changes caused by contract negotiations.

Key components of summary master schedules could include significant items from the following list:

- Key elements of contract work
- Test articles
- Deliverable hardware, software, and documentation
- GFE/customer-furnished equipment deliveries
- Key program and customer milestones/events over the life of the contract
- Subcontract elements

Intermediate Schedule

The intermediate schedule represents program activities, milestones, and phases at a level of detail between, but vertically traceable to, the Summary Master Schedule and Detailed Schedule. It frequently serves as the basis for functional organization manager, product team leader, and CAM staffing, resource de-confliction, and schedule management. In a product team environment, the intermediate schedule often becomes the product team's summary schedule. Often, the Intermediate Schedule is a "roll-up" of the detailed IMS model in the same tool, which makes performing status and providing traceability significantly easier. However, regardless of whether or not the Intermediate Schedule is maintained in the same tool as the detailed schedule, it should always be traceable to the detailed schedule. Intermediate schedules serve as communication tools that can take several forms depending on the current programmatic needs.

Detail Level Schedule (IMS Network)

The detail level schedule is the lowest tier of tasking and the source of the data that drives the Summary Master and Intermediate Level Schedules. The detail level schedule subdivides authorized work into a logical sequence of time-phased and networked tasks. Programs plan these tasks in terms of work scope that represents meaningful indicators of accomplishment. Developed and used by functional organization managers, product team leaders, and CAMs, this schedule is normally supported by lower level schedule details, such as Quantifiable Back-up Data (QBD), and is normally updated for status weekly or bi-weekly and reported at least monthly to provide overall status and forecasting.

Examples

The following example (Figure 4.3-1) is of a Detail Level schedule.

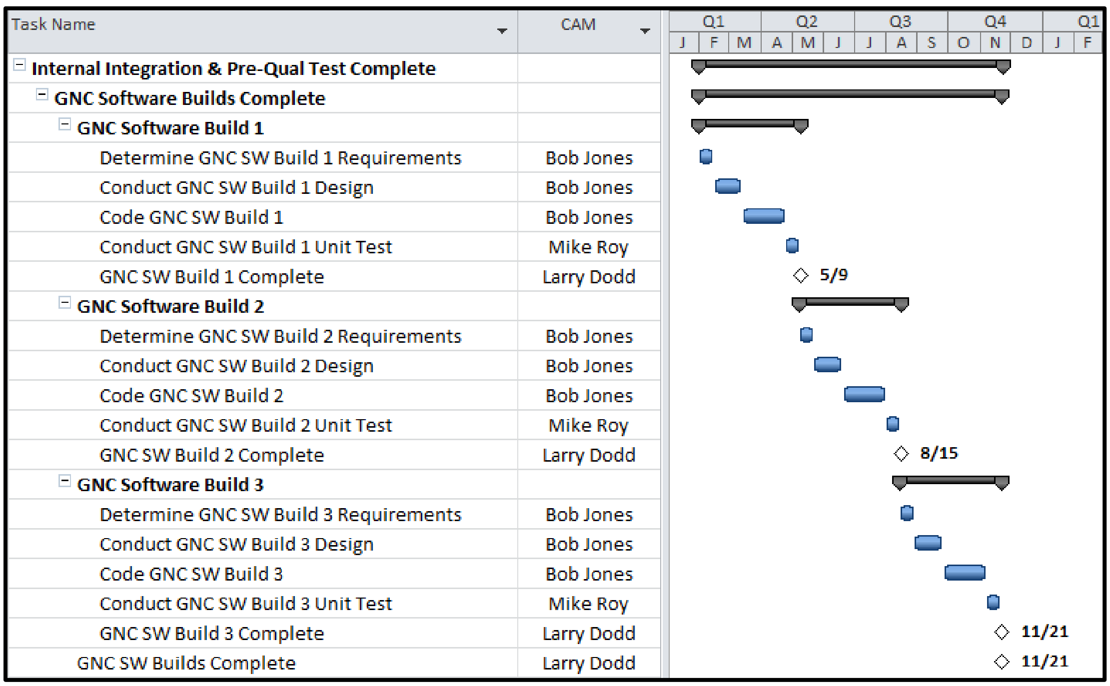


Figure 4.3-1 Example of a Detail Level Schedule

The following example (Figure 4.3-2) is an Intermediate Level schedule showing the Bob Jones control account.

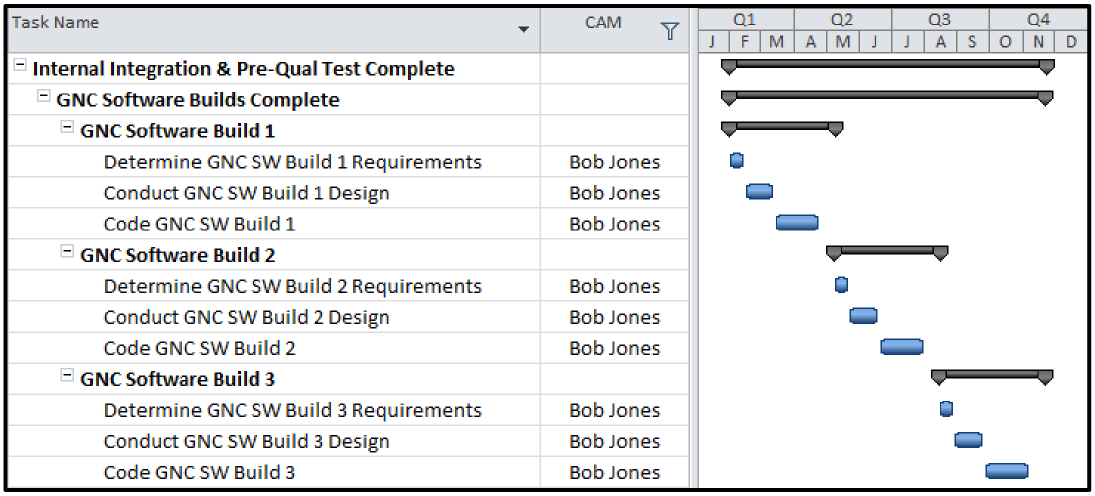


Figure 4.3-2 Example of an Intermediate Level Schedule

The following example (Figure 4.3-3) is a Summary Master Level schedule showing the key phases and milestones.

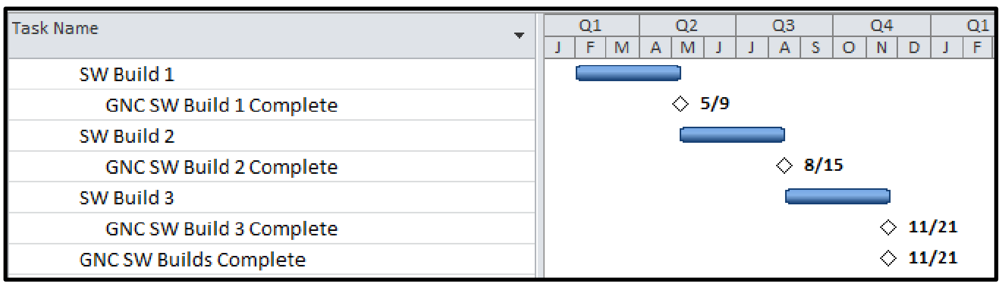


Figure 4.3-3 Example of a Summary Master Level Schedule

Optional Techniques

The Summary Master and Intermediate level schedules may or may not include baseline and/or forecast information.

Things to Promote

Regardless of methodology or tools used, always ensure date traceability between all levels of the schedule hierarchy. The WBS, IMP or other coding field relationship may not always exist between the different hierarchical levels of the IMS so the planner/scheduler should use the IMS Supplemental Guidance to record and document relationships not self-documented in the IMS.

Related Topics

[Top-Down v. Bottom-Up Planning](#)
[IMS Architecture](#)
[Managing using the IMS](#)

4.4 Schedule Baseline v. Forecast

Manager's View

To be a useful management tool, the IMS should have an original plan (i.e. "baseline") against which current status (i.e. "forecast") can be compared. The ability to compare baseline versus forecast dates provides a useful tool for executing and understanding the current state of the program. Both the schedule baseline and the forecast are under frequent maintenance. The baseline schedule is subject to formal change control and changes less frequently while the forecast schedule changes with each status cycle. Each task in the IMS has both baseline and forecast dates.

Description

The initial schedule development results in the program baseline. It becomes the foundation for earned value performance measurement. It must contain the entire scope of the contract including all contractual requirements. It is consistent with the most likely expectations of performance at the time of establishment. It is under configuration control and maintained to ensure consistency with the program's contractual requirements. It is the schedule that is subject to an Integrated Baseline Review (IBR), as applicable.

Conversely, the forecast is updated, by the CAMs, during each status period to reflect program performance and an executable path forward. This schedule forecast becomes the foundation for Estimates to Complete (ETCs). The schedule statusing frequency is defined in the contractor's EVMS description and supplemental program directives or Schedule Management Plan (SMP) and results in recalculating the schedule after each status cycle. This process should occur at least every month, if not more often. The recalculation typically results in revised forecast dates, float values, and date variances on each task and a potential revision of the program critical and driving paths.

The forecast and baseline may be captured in the same schedule or be in separate versions of the schedule depending on the tool specifics. Regardless, each task in the baseline schedule should be captured in the forecast schedule.

The difference between the forecast and baseline is reflected in duration or start/ finish date variance. This type of duration-based finish variance analysis should be reconciled with CPR-based variance analysis (i.e. cumulative and current period BCWS - BCWP) and other schedule analysis metrics. Comparisons between the baseline and forecast schedules provide a fundamental basis for generating schedule workarounds or detailed recovery steps for applicable late activities and their impact as the program progresses over time.

Things to Promote

- Verify that the baseline and forecast dates are identical at the time that the baseline is established"
- Ensure that the baseline is maintained through change control consistent with program requirements and the applicable system description.
- Compare the forecast schedule to the baseline schedule to assist in management analysis and forecast of contract performance.

Things to Avoid

- Changing the baseline to avert unfavorable schedule/EVMS Metrics or to avoid reporting schedule delays.

- Not maintaining the baseline consistent with scope changes.
- Not keeping the forecast schedule current with approved scope changes, status, task forecasts, and workarounds as applicable.
- Avoid undocumented and/or unapproved changes to the baseline.

Related Topics

Schedule Margin
Forecasting
Schedule Acceleration Techniques
Baseline Change Management
Program Schedule Reviews

4.5 Top-Down v. Bottom-Up Planning

Manager's View

Top-down and Bottom-up planning are two complimentary planning processes. Employ a combination of both during IMS development. The top-down approach defines the overall program structure and objectives and provides guidance as to where in the schedule certain scope belongs. A bottom-up approach ensures that the IMS contains all of the detailed work scope and hand-offs necessary to achieve the program objectives. The Bottom-up process allows for negotiating changes to program assumptions defined in the Top-Down effort and a process to reconciling the positions.

Description

Top-down planning identifies the customer and internally driven goals and establishes the desired period of performance. This development may continue to decompose successive levels of detail until reaching the task or work package level, or may choose to remain at a higher level, requiring the remaining detail breakdown during bottom-up planning.

Depending on the methodology and depth of the top-down development, task owners conduct bottom-up planning at the detail task level and all task characteristic development such as task duration, precedence logic, resource identification and assignment. Validation of the program objectives, hand-off agreements, resource de-confliction, and a basis of estimate comparison occurs during the bottom-up planning and scheduling efforts. Both top-down and bottom-up planning require appropriate program team member participation in order to ensure a successful completion of the Performance Measurement Baseline (PMB).

Examples

The following example (Figure 4.5-1) shows program milestones and the associated desired period of performances established with a Top-Down planning approach.

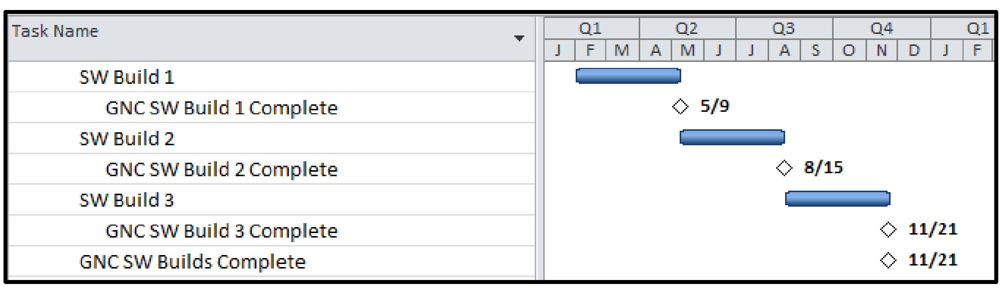


Figure 4.5-1 Top-Down Planning example demonstrating desired Periods of Performance

The following example (Figure 4.5-2) shows detailed tasking developed in a Bottom-Up approach that support the Summary Master Schedule details above (Figure 4.5-1).

Task Name	CAM
Internal Integration & Pre-Qual Test Complete	
GNC Software Builds Complete	
GNC Software Build 1	
Determine GNC SW Buils 1 Requirements	Bob Jones
Conduct GNC SW Build 1 Design	Bob Jones
Code GNC SW Build 1	Bob Jones
Conduct GNC SW Build 1 Unit Test	Mike Roy
GNC SW Build 1 Complete	Larry Dodd
GNC Software Build 2	
Determine GNC SW Buils 2 Requirements	Bob Jones
Conduct GNC SW Build 2 Design	Bob Jones
Code GNC SW Build 2	Bob Jones
Conduct GNC SW Build 2 Unit Test	Mike Roy
GNC SW Build 2 Complete	Larry Dodd
GNC Software Build 3	
Determine GNC SW Buils 3 Requirements	Bob Jones
Conduct GNC SW Build 3 Design	Bob Jones
Code GNC SW Build 3	Bob Jones
Conduct GNC SW Build 3 Unit Test	Mike Roy
GNC SW Build 3 Complete	Larry Dodd
GNC SW Builds Complete	Larry Dodd

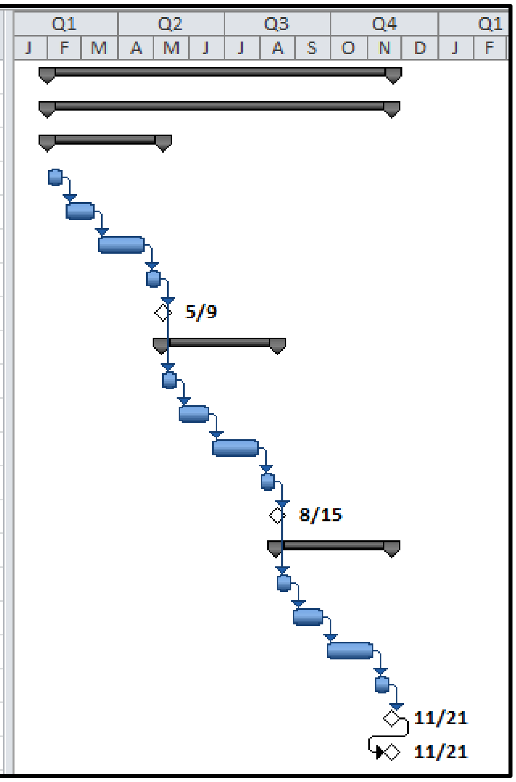


Figure 4.5-2 Example of Bottom-up Planning, supporting Top-down Planning from Figure 4.5-1 above

Things to Promote

Consider using the WBS and/or IMP structure architecture to aid in the Top-Down and Bottom-up planning effort during IMS development.

Ensure that the IMS baseline dates support contractual and purchase order delivery dates, and the baseline represents an achievable plan.

Plan the bottoms-up details for the material budgets in accordance with the Programs accrual/voucher policies.

Ensure external dependencies are reflected in the program's detail IMS.

During Bottom-Up planning, ensure that alignment with Top-Down program goals is continuously reconciled and assessed to ensure the schedule supports the overarching program objectives.

Consider past performance as a basis of estimate when developing the IMS. Obtain value for current detailing efforts by researching performance of like efforts, interviewing task owners and applying factors of complexity and risk to the current effort.

Things to Avoid

Avoid relying on just one of the two approaches (i.e. Top-Down or Bottom-Up) to create the IMS.

Related Topics

Rolling Wave Planning
Vertical Integration and Traceability

Schedule Hierarchy
Task Coding

5 Schedule Modeling Techniques

This section contains the following chapters.

5.1 Task Naming Convention

Manager's View

Task names describe the actual work scope being performed as part of the associated WBS/SOW. They should identify the required action and purpose that makes it unique from other tasks in a schedule. Consistent and clear task naming conventions increase the usability and effectiveness of an IMS.

Description

The quality of task naming conventions significantly affects the efficiency in which a schedule is used. For example, performing name searches for similar tasks in multiple parts of a schedule is easier when the naming structure is well defined and consistent.

Example

Below are examples of typical task names (Figure 5.1-1).

Unique ID	Task Name
1	Conduct Regression Test Phase 5
2	Execute Mock 3
3	Build Client Cutover Practice
4	Write Scripts for Supplemental Test Phase 1
5	Conduct UAT Scenarios Requirements Mapping
6	Conduct UAT Scenarios Workshop
7	Prepare for UAT TRR
8	Perform Defect Resolution

Figure 5.1-1 Examples of Typical Task Names

Optional Techniques

To aid in navigation and schedule analysis, task owners may opt to add a product or team descriptor to the beginning of a task name. This aids in ensuring the task is identifiable outside of its summary structure.

Things to Promote

Define the task (scope) and its output (deliverable) whenever possible in the task name.

Write descriptive tasks names so that users understand the content without the summary task structure to aid in descriptive clarification.

Task names are most effective when they begin with a present-tense action verb and describe the scope in such a manner that clearly defines the intent, such as "Analyze Flight Survivability Test Data."

To clarify the meaning of each term used in the IMS, use an IMS terminology definition sheet, consistent with the terminology in the IMP (as applicable) and Statement of Work (SOW). This makes task names easier to understand and encourages schedulers to use these terms consistently throughout the IMS. For example, clearly define frequently used terms such as Complete, Draft, and Review for easy understanding of each task's objective. Include the IMS terminology definition in the IMS Supplemental Guidance or data dictionary.

The use of consistent naming formats and standard definitions facilitate better status collection when determining a task's intent and progress achieved. These techniques also make the use of filtering, sorting and pulling work product metrics more efficient. For example, it is easier to pull metrics for items such as Scripts, Payloads, or Assemblies when these words have the same meaning and in the same format for all tasks.

Things to Avoid

Avoid using duplicate Task Names in the IMS. Each task should have scope clearly defined and be able to stand alone without the need for support from summary task descriptions in order for the task's scope to be determined.

Avoid common mistakes when naming tasks, as illustrated in the following examples:

Inconsistent

- "PL11-Planning Reports"- does not describe the action. Better example would be "PL11-Develop Plan for producing CDRL A008 reports
- "Training Clients"- does not relate to specific training and can be confused with other training referenced without specific descriptions. Better example would be "Train Clients with TRN-3400 courseware"
- "Perform Defect Resolution"- does not relate to a particular item, unit or perhaps type of defect. Better example would be "Update Reliability Model with Apr-2010 Field Defect data"

Poorly defined and unclear

- "Write Scripts"- especially problematic when reviewing similar tasks, filtered and sorted without summary task or using code category descriptions. Better example would be "CSCI AAX-Write Test Scripts for Test Y".

Identified with incorrect format

- Incorrect format: "Network Connectivity Readiness". Correct format: "Perform and Document Network Connectivity Readiness".

Related Topics

Task Coding
Managing using the IMS
Desktop Procedures

5.2 Task Duration

Manager's View

Duration is defined as the amount of time required to complete a task. A consistent and uniform unit of measure, typically workdays, is used to represent duration in the IMS to facilitate maintenance, analysis, and management of the IMS. Durations are modeled with a level of detail appropriate to support technical achievement and effective program management.

Description

The duration of a task is the number of business hours or days estimated to complete a task. Duration can be entered in minutes, hours, days, elapsed days, weeks, months or years. Most schedules identify duration in days that are attributed to the working calendar of the contractor's accounting system. Duration is not the same as work or budget allocated to a task. However, duration should be consistent with the required work effort and the amount of resources (i.e., number of people) assigned to the task.

The duration of a task should provide sufficient detail promoting clear understanding of the scope and facilitating status throughout the program. It is important to break down workflow with enough detail to identify a critical path for the entire contractual period of performance.

Baseline Duration

Baseline duration identifies the original span of time for each task, at the time when establishing or updating the program's baseline. These durations reflect the ability to execute these tasks of known scope and conditions with acceptable risk. Make task performance comparisons to the original task duration during the execution phase to understand the quality of the original estimated duration. Use these variances to determine the validity of similar future work effort projections.

Actual Duration

Actual duration is the number of workdays that have passed from the Actual Start of a task up to Time Now (in-process tasks) or the Actual Finish (completed tasks). During the status process, all new current period Actual Starts and Actual Finishes should be updated in the IMS. If a task has an Actual Start but is not finished, then a new forecast finish date is established by either identifying the Estimated (forecast) Finish or by adjusting Remaining Duration (which is typically the preferred method depending on your scheduling tool and process).

Remaining Duration

Remaining duration is the number of workdays forecasted to complete an in-process task or a task in the future that has not started. Task owners update remaining duration because it helps them determine how much work remains instead of meeting a calendar date. Focus on remaining duration to calculate the amount of work time from Time Now to the forecast finish date.

Note on Elapsed Days: Baseline, Actual and Remaining Duration will honor the non-working day calendars assigned to the project, resource or task. However, all scheduling software tools offer the capability of using elapsed duration. Tasks using elapsed duration will continuously schedule work irrespective of the non-working day calendars applied. As an example, if work is going to be performed over a weekend the task duration could be switched to elapsed duration which would result in the task scheduling work on Saturday and Sunday. However, the use of elapsed days will impact the calculation of Total Float, possibly making it more challenging to determine Critical and Driving Paths depending on the capabilities of the scheduling tool used.

Therefore, programs should only use elapsed days when appropriate. If Elapsed Days are used in the IMS it is good practice to document within the IMS and the IMS Supplemental Guidance Document the reason why elapsed days are being used versus the conventional calendar-based duration.

Example

Task Name	Baseline Duration	Actual Duration	Remaining Duration
Duration Examples	**60 days**	**31 days**	**29 days**
Completed Task	15 days	21 days	0 days
In-Process Task	20 days	10 days	11 days
Unstarted Task	15 days	0 days	18 days

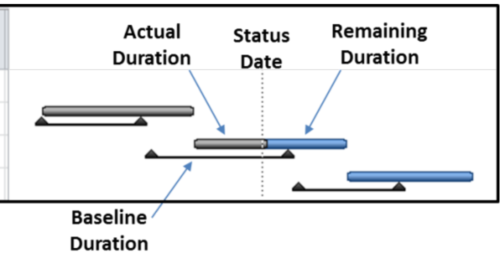


Figure 5.2-1 Example Schedule demonstrating status update to Time Now

Things to Promote

Ensure that the level of detail in the IMS is appropriate to manage the effort. Higher duration tasking may not provide the necessary precision for future measurement of work completed without significant additional effort on the part of the program.

A single standard unit of time for measuring duration (hours, days, weeks, months, etc.) should be used consistently throughout the IMS. This will help prevent internal calculations of total and free slack from potentially being slightly different within the same logic path of scheduled tasks.

Ensuring Accurate Forecasts - Focus on remaining work versus specific dates during the status process to ensure task owners are accurately modeling the “to go” work profile.

Analyze duration growth throughout the program lifecycle for use as a basis of estimate in forecasting future task durations.

Ensure that durations capturing team hand-offs are adequate to capture the necessary fidelity of products.

Ensure that task owners use a consistent methodology for determining durations across the program. This allows for easier evaluation of float and or promotes the consistent application of min/max durations when conducting Schedule Risk Assessment (SRA).

Consider documenting the methodology in which performance will be earned on large duration tasks.

Ensure remaining duration is updated for every in-progress task.

Things to Avoid

Increasing duration estimates with the task owner’s own personal buffer or margin. This can result in masking/consuming program flexibility which could be utilized to perform high risk efforts.

Avoid arbitrarily breaking tasks into smaller durations to meet predetermined metrics objectives if the increased level of detail is not necessary to effectively manage the task.

Related Topics

Schedule Margin
Forecasting

5.3 Relationships / Logic

Manager's View

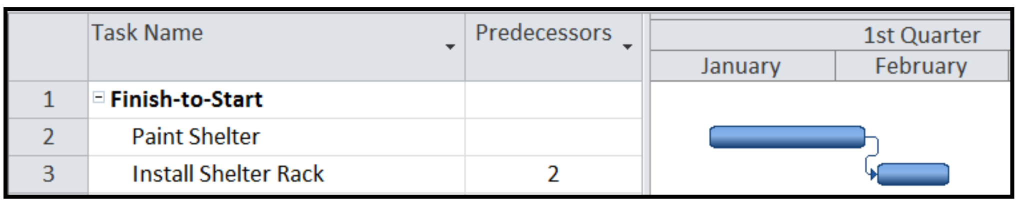
After schedule tasks are created, they are "linked" to show their logical dependencies. These logical ties in combination with the task durations, date dependent constraints and lags define the anticipated program workflow and are the foundation for the schedule date calculations, and critical path. All discrete tasks/milestones should have at least one predecessor and one successor as even one missing logical tie could adversely affect the program's ability to successfully execute the project.

Description

In scheduling terms, two tasks that are linked are referred to as a Predecessor and a Successor. Execution of the Predecessor(s) will allow the execution of the Successor.

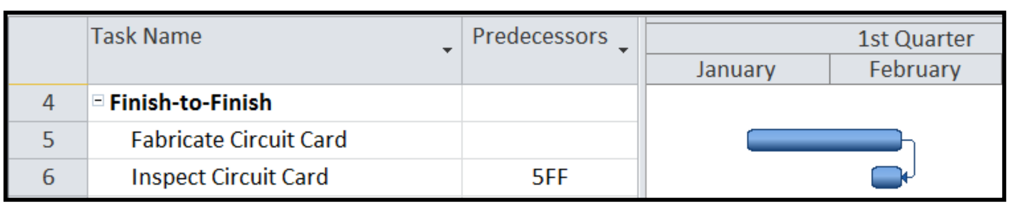
There are four scheduling relationship types used for linking: Finish-to-Start (FS), Finish-to-Finish (FF), Start-to-Start (SS) and Start-to-Finish (SF). True relationships should be the driving factor in determining which relationship type to use to reflect how the work is performed. Start-to Finish logic, while available within most scheduling tools is extremely rare and should be avoided. In most scenarios, the Start-to-finish logic can be more appropriately modeled by utilization of another relationship type (FS, FF or SS).

Examples



	Task Name	Predecessors
1	**Finish-to-Start**	
2	Paint Shelter	
3	Install Shelter Rack	2

Figure 5.3-1 Finish-to-Start:
Task 3 (Install Shelter Rack) can start after Task 2 (Paint Shelter) completes.



	Task Name	Predecessors
4	**Finish-to-Finish**	
5	Fabricate Circuit Card	
6	Inspect Circuit Card	5FF

Figure 5.3-2 Finish-to-Finish:
Task 6 (Inspect Circuit Card) cannot complete until Task 5 (Fabricate Circuit Card) is complete.

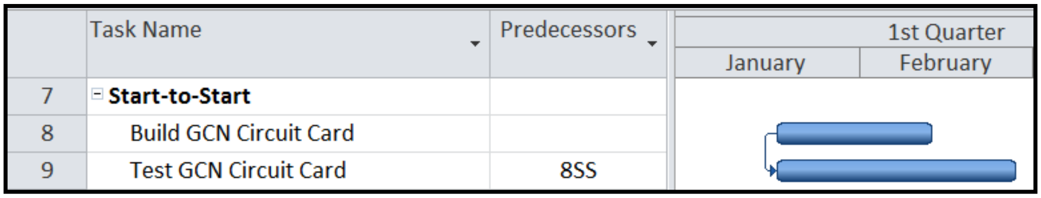


Figure5.3-3 Start-to-Start:
Task 9 (Test GCN Circuit Card) cannot start until Task 8 (Build GCN Circuit Card) has started.

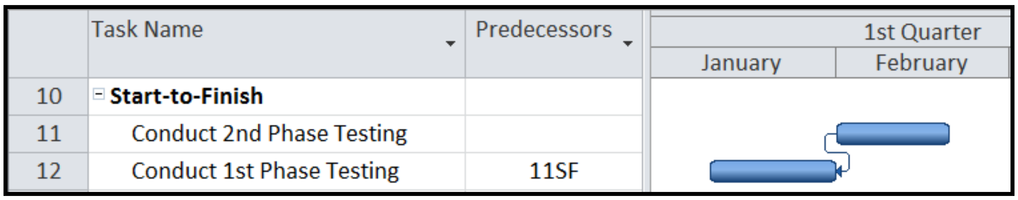


Figure 5.3-4 Start-to-Finish:
Task 12 (Conduct 1st Phase Testing) cannot complete until
Task 11 (Conduct 2nd Testing) has started.

Calculations

Refer to the Critical Path Method (CPM) section for an explanation of how these relationships play into the forward and backward pass calculations.

Things to Promote

Ideally, programs should structure their IMS with predominantly Finish-to-Start (FS) relationships. However, programs should ensure that the logic types used in the IMS accurately model the real task relationships.

It is recommended that each activity have at least one Finish-to-Start or Start-to-start predecessor and one Finish-to-Start or Finish-to-Finish successor.

Ensure tasks have at least one non-Start-to-Start successor. If a task only has Start-to-Start succeeding relationships, then its finish date does not actually drive downstream work. See Figure 5.3-5 below.

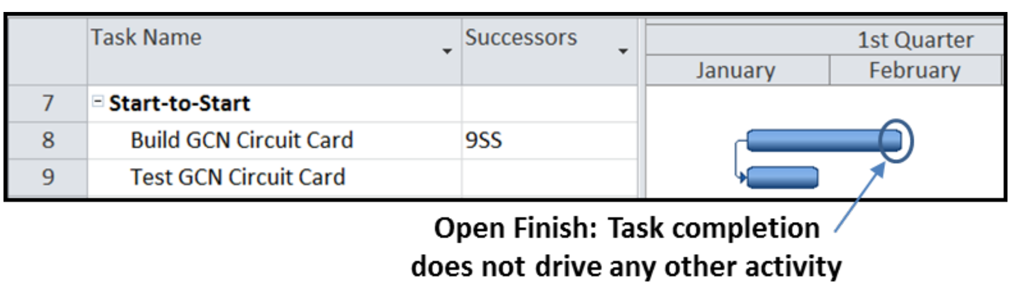


Figure 5.3-5 Example missing non-Start-to-Start Successor

Ensure tasks have at least one non-Finish-to-Finish predecessor. If a task only has Finish-to-Finish preceding task relationships, then its start date is not actually driven by preceding work. See Figure 5.3-6 below.

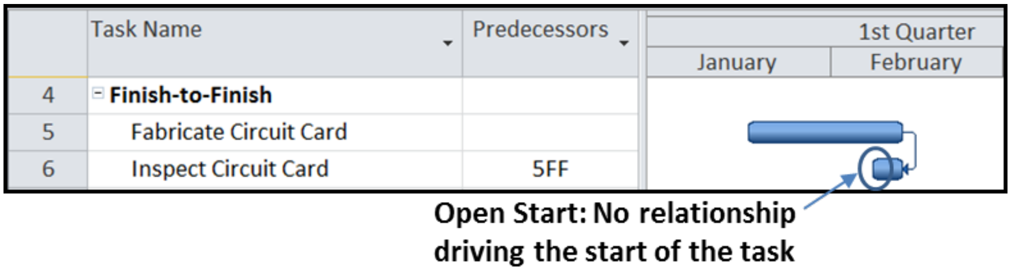


Figure 5.3-6 Example missing non-Finish-to-Finish Predecessor

Note: Caveats to these recommendations are receipt milestones/activities (which may not require a predecessor) and delivery milestones/activities (which may not require a successor).

Things to Avoid

Avoid linking tasks arbitrarily out of convenience or to satisfy a metric. Each link should accurately represent how the work is intended to be accomplished on the project.

Avoid unnecessarily using Start-to-Finish relationships.

Related Topics

Lead / Lag Time
Vertical Integration and Traceability
Schedule Visibility Tasks (SVT)

5.4 Lead / Lag Time

Manager's View

Leads and lags are scheduling techniques used in modeling a delay (lag) or planned overlap (lead) in the schedule network. It is important that lead and lag relationships only be used when the values represent real situations of needed acceleration or delay time between activities. Misuse of leads/lags in the IMS may have unintended consequences.

Description

Leads and Lags are part of a logic driven schedule that represents a delay/wait time (Lag) or planned overlaps (Lead) between two schedule tasks and/or Milestones. Used correctly, Lags allow the schedule to model how work is accomplished. In general, creating separate tasks by identifying logical break points that will better model how the work is accomplished is a preferred method over using Leads. Unnecessary use of Lead and/or Lag can be indicative of a schedule that does not have enough fidelity to model the Hand-offs from one task to another properly.

Lag modifies a logical relationship that directs a delay in a successor activity. Enter Lag as a positive percentage or time (days, hours, minutes, etc.). Lead is a modification of a logical relationship that allows an acceleration of the successor activity. Enter Lead as a negative percentage or negative time (days, hours, minutes, etc.). The values for Lead/Lag should be consistent with the time units used with the successor task (days, hours, weeks, etc.)

Note on leads: The inaccurate compression or overlapping of schedule tasks can easily result from the misuse of leads. To counter this misuse, the government has strict tolerances around the use of leads. Therefore, programs may want to consider alternative methods (i.e. break down the task to a lower level of detail) of modeling task flow that do not require the use of Leads.

Examples

Lag: In Figure 5.4-1, Task 3 (Install Shelter Rack) can start 5 days after Task 2 (Paint Shelter) completes.

In this example, the lag represents the time required for the paint to dry on the shelter. During this lag period, no resources are used.

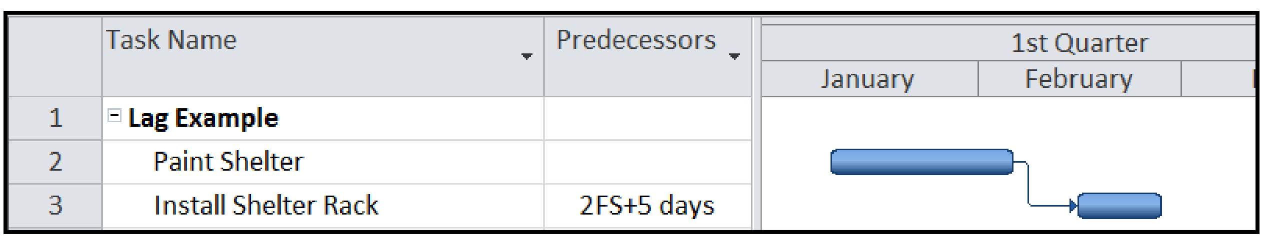
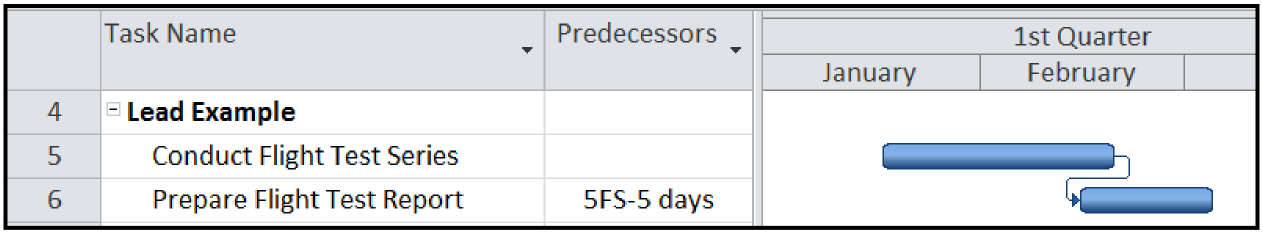


Figure 5.4-1 Lag Example

Lead: In Figure5.4-2, Task 6 (Prepare Test Flight Report) may start 5 days before Task 5 (Conduct Flight Test Series) completes.



	Task Name	Predecessors
4	Lead Example	
5	Conduct Flight Test Series	
6	Prepare Flight Test Report	5FS-5 days

Figure 5.4-2 Lead Example

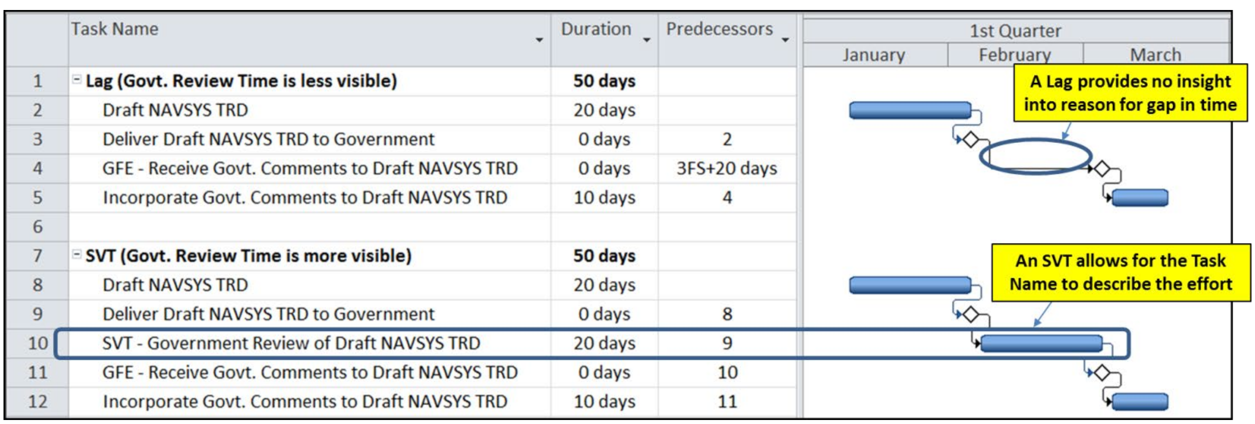
Note: Most scheduling software tools support the assignment of Lags and Leads as a percentage versus a unit of time. Keep in mind that the use of percentage-based leads may cause undesirable schedule implications, as the impact of the lead is proportional to the task's duration (which can fluctuate during execution and may render the percentage as inaccurate).

Optional Techniques

Programs may want to consider using a Schedule Visibility Task (SVT) versus a lag. If the answer to one or more of these questions is yes, an SVT may be appropriate:

- Can you ascertain status information (such as remaining time or progress to Time Now) while the lag is in process?
- Is it likely that the actual length of the delay will be different from the originally planned delay?
- Is the lag likely to show up on the Critical Path/Driving Path?
- Would it be beneficial to track the forecast of the delay against the baseline delay time?
- Will the lag adversely affect any Vertical Integration and Traceability to other schedules or systems?

SVT v. Lag: Figure 5.4-3 demonstrates how using an SVT versus a Lag can provide enhanced schedule visibility.



	Task Name	Duration	Predecessors
1	Lag (Govt. Review Time is less visible)	50 days	
2	Draft NAVSYS TRD	20 days	
3	Deliver Draft NAVSYS TRD to Government	0 days	2
4	GFE - Receive Govt. Comments to Draft NAVSYS TRD	0 days	3FS+20 days
5	Incorporate Govt. Comments to Draft NAVSYS TRD	10 days	4
6			
7	SVT (Govt. Review Time is more visible)	50 days	
8	Draft NAVSYS TRD	20 days	
9	Deliver Draft NAVSYS TRD to Government	0 days	8
10	SVT - Government Review of Draft NAVSYS TRD	20 days	9
11	GFE - Receive Govt. Comments to Draft NAVSYS TRD	0 days	10
12	Incorporate Govt. Comments to Draft NAVSYS TRD	10 days	11

Figure 5.4-3 Example of using an SVT in place of a Lag

Things to Promote

If the schedule is accurately modeled in a way that depends on a large number of leads/lags, then document the modeling methodology in the program's IMS Supplemental Guidance.

Document the purpose of each lead/lag within the IMS (i.e. in a field defined by the user) to facilitate the ease of IMS status and analysis.

Consider alternative schedule-modeling techniques to using lags or leads including, but not limited to, the following:

- Lags – Consider whether it is more appropriate to use a Soft Constraint or, where applicable, an SVT versus a Lag.
- Leads – Consider decomposing (splitting) tasks to a lower level of detail to create logical Hand-off points. The logical Hand-off points could then be linked finish-to-start removing the need to use a lead.
- Consider creating standard justification codes that describe scenarios where lags/leads may be commonly used (such as material lead times). This can increase consistency in the usage of lags and leads.

Review and update the duration of each applicable lead and lag during every status cycle.

Things to Avoid

Avoid using lags in place of tasking representing budgeted work.

Avoid using Lead/Lag to manipulate tasks to meet a certain date. Lags/Leads should be used to represent real workflow requirements versus specific dates.

Avoid using Leads when possible.

Related Topics

Task Constraints
Task Duration
Horizontal Traceability
Schedule Visibility Tasks (SVT)

5.5 Task Constraints

Manager's View

Constraints fine-tune a logic-driven schedule by establishing date restrictions based on factors such as component delivery, near term resource availability, or contractual obligations. Used correctly, constraints help reflect realistic and accurate start and finish dates based on the need dates and requirements of a project. Misuse of task constraints in the IMS may have unintended consequences of overriding or invalidating the network logic and distorting the total float and critical path.

Description

Constraints are restrictions set on the start or finish dates of tasks. These restrictions either establish dates, place conditions on how dates are calculated, and/or affect total float calculations within the schedule. As a result, dates and total float values may calculate differently when performing the forward pass and/or backward pass in a logic network schedule.

After assigning logic and duration to all activities in a schedule, their start and finish dates and float values are calculated based on the forward and backward pass through the logic network. The forward pass calculates the Early Start (ES) and Early Finish (EF) dates for all milestones and activities. The backward pass calculates the Late Start (LS) and Late Finish (LF) dates for all milestones and activities. Applying constraints to tasks and milestones in the schedule may impact these network calculations.

Early start and early finish dates are the scheduled or forecast dates that reflect when a task or milestone can occur. Late Start and Late Finish dates are the need dates that reflect the latest a task or milestone can occur without delaying the end of the program or constraint date. Total Float is the mathematical difference between an activity's Late Finish Date and Early Finish Date (in workdays, based on the calendars applied to the task).

Typically, planners/schedulers model tasks to occur as soon as possible, allowing the network logic to determine the earliest and latest dates that tasks can start and finish based on their dependencies and task durations. However, some circumstances often necessitate the need to use constraints in the IMS.

Soft Constraints

Soft constraints allow logic to drive the schedule to the right (i.e. restricts only movement to the left) on the constrained task.

Hard Constraints

Hard constraints do not allow the logic to drive the schedule (i.e. either restricts all movement or restricts movement to the right) on the constrained task.

Note on Deadlines/Targets: some tools have constraint options that impact only the backwards pass allowing for the assigning of a deadline or target date. These options are used to help calculate the total float against contract requirements and are not considered hard constraints as the tasks can move to the right.

Example

Refer to the Schedule Calculation Algorithm chapter for examples.

Things to Promote

Use a soft constraint for date dependent activities.

Document reasons for using constraints in the schedule.

Use constraints affecting the early dates to reflect resource restrictions.

Validate that the schedule model contains accurate and complete logic ties with the objective of highlighting and removing unnecessary constraints.

Ideally, most tasks in a schedule start and finish as soon as possible so that network logic and planned durations drive the schedule dates. However, there are occasions when constraints should be used. In these cases, the use of constraints should be well documented and not replace logic.

Soft Constraints

Pay special attention to soft constraints representing accurate dates in the schedule for near-term tasks.

Examples of when to use soft constraints are:

- Identifying projected start dates for tasks that are not integrated into the prime schedule (e.g., material deliveries).
- Identifying dates for tasks that need to be scheduled based on other elements or contractor dates (e.g., testing in a shared facility, availability of machinery, availability of funding or resources).
- Identifying projected finish dates for tasks that cannot be completed until other work that is not integrated into the prime schedule is completed (e.g., receiving all necessary user management roles from site prior to completing assignments).

Things to Avoid

Do not use a lag in place of a soft constraint for date-dependent activities.

Do not assume that all scheduling tools handle 'constraints' in the same manner (in terms of how the constraint affects the IMS). Example: in some tools applying an 'As Late as Possible" type constraint to a task will only remove the free float between the task and its direct Successors (i.e., those tasks tied as an immediate successor to the task). In other tools the same application will remove not only the free float between the task and its immediate successors but will also remove all free float in the successor path.

Hard Constraints

Avoid the inappropriate use of hard constraints, favoring more flexible soft constraints where practical. Hard constraints prevent tasks from being moved by their dependencies and, therefore, prevent the schedule from being logic driven. While uncommon, there are tasks that are not affected by predecessor efforts, but instead are virtually locked in place such as the opening ceremony for the Olympics. If Hard constraints are used, reasoning for the need should be documented in the IMS notes or other field defined for that purpose. As a result, the critical path and other analysis may be adversely affected. Generally, the use of hard constraints does not support a credible risk assessment and produces unreliable results in a Schedule Risk Assessment (SRA).

Instead of hard constraints consider soft constraints for the following reasons:

- Program milestones yield accurate float values throughout the schedule.

- Task early dates are always driven by their precedence logic.
- Enables the ability to monitor portions of the schedule that are prone to schedule slip by tracking total float.

Related Topics

Schedule Calculation Algorithm
Relationships / Logic
Lead / Lag Time

5.6 Milestones

Manager's View

Milestones are specific definable accomplishments or starts in the logic network, recognizable at a particular point in time. Milestones have zero duration and do not consume resources. Milestones may mark the start and/or finish of an interim step, event and/or program phase, making them convenient indicators of attaining program objectives. To ensure milestones reflect the impact of related task delays or acceleration, programs establish milestone forecast dates through precedence logic.

Description

Program Milestones

Program milestones begin to take on definition during the development of the Integrated Master Plan (IMP) events and are generally defined and imposed upon a program by the customer. These events establish the top-level control points for work scope performance, product development, and product and service definition and are often identified in the Statement of Work (SOW) or other contractual documents.

Typically, an IMS includes a program start milestone and a program finish milestone. The start milestone is used as a predecessor for work that starts at the beginning of a program. The finish milestone is the successor for the end of all logic paths. Milestones identifying major events are also usually included, such as Systems Requirements Review (SRR), Preliminary Design Review (PDR), Critical Design Review (CDR), and Production Readiness Review (PRR). The completion of other major events such as major test events and demonstrations, achieving flight readiness, or first flight, in the case of an aircraft program, may also be incorporated.

Toll-Gate Milestones

Toll-gate milestones often referred to as intermediate or book-end milestones are defined occurrences that constitute the start or completion of work scope and serve as an objective criterion for determining accomplishment. Toll-gate milestones are based on specific program, integrated product team, or performing organization requirements to perform to the defined work scope. These milestones are usually tied to tasks representing major events or program milestones in the IMS.

Examples

Program Milestones

Below is an example of typical program milestones included in an IMS (Figure 5.6-1).

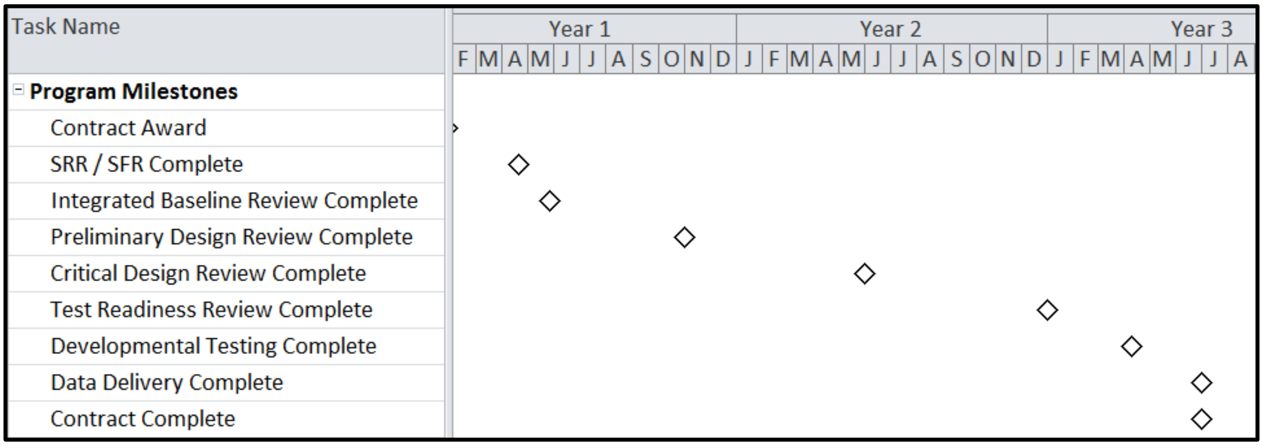


Figure 5.6-1 Example of typical Program Milestones in an IMS

Toll-Gate Milestones

An example of a toll-gate milestone (Figure 5.6-2) is “Consolidated Drawing Package for CDR Completed” and “Consolidated Software CSCI Package for CDR Complete” tasking. Instead of linking all hardware and software efforts directly to toll-gate milestone task 14, the software efforts are “collected” by a software toll-gate milestone, and hardware is likewise “collected” by a hardware toll-gate milestone. This clarity reduces the total number of predecessors to the Technical Package for CDR Completed, task 14, in favor of a smaller number whose task name identifies the portion of the IMS leading to the milestone. This clarity facilitates analysis, especially when performing a driving logic path trace to determine the cause of an impacted task.

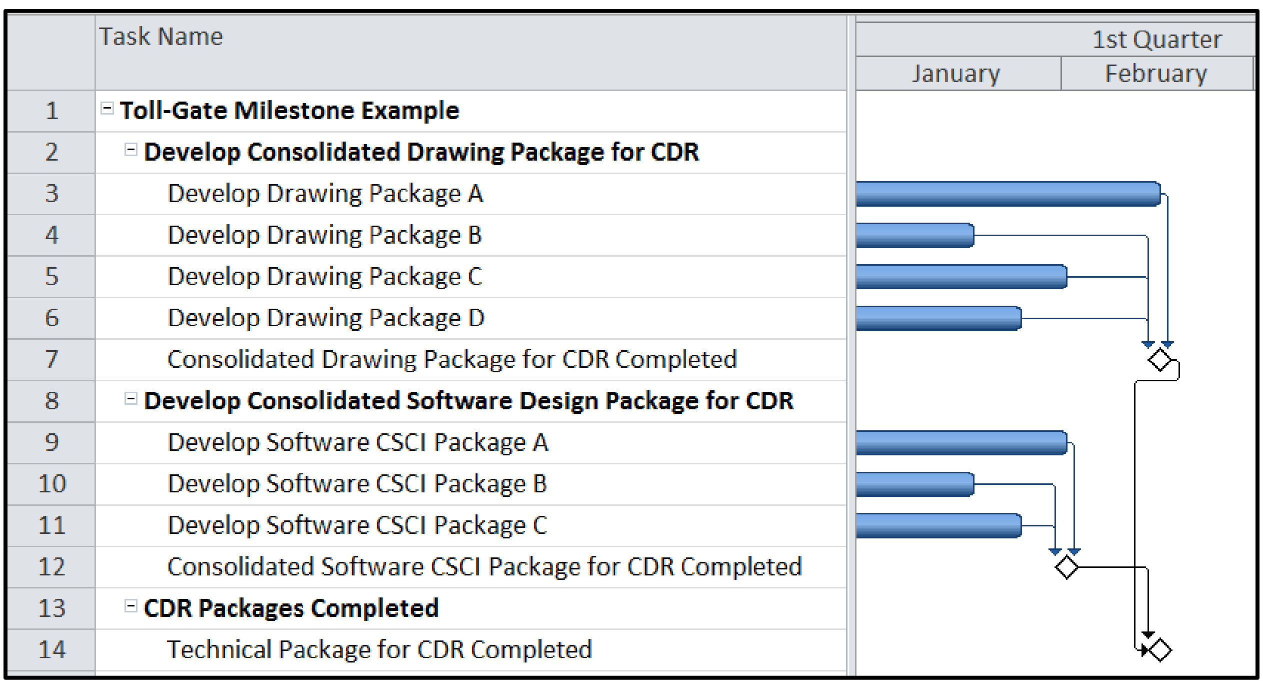


Figure 5.6-2 Examples of Toll-Gate Milestone use in an IMS

Note: intent on the example (Figure 5.6-2) is to demonstrate how multiple inputs to a Toll-Gate Milestone may be organized such that schedule analysis is enhanced. In this example, it is clear that of the 2 milestones feeding task 14, that milestone task 7 is being driven by task 3 in the hardware development area of the IMS.

Optional Techniques

Assign soft constraints that impact the backwards pass to milestones, as appropriate, to enforce the target dates the program commits to supporting. Instead of the baseline and deadline constraints simply mirroring the contractual requirements, either, or both, can be set to enforce earlier "internal" goals. This more stringent control enables the team to monitor the total float available by setting earlier constraints and adjusting the constraints in a controlled fashion as necessary.

Things to Promote

Program Milestones: For best visibility, locate major program milestones at the top of the IMS.

Toll-Gate Milestones: Use toll-gate milestones to provide further clarity for logic path ending points. By linking toll-gate milestones to tasks representing major events or program milestones, excessive relationship ties are avoided. Using an excessive number of logical relationships to the same task or milestone complicates schedule analysis. These milestones are convenient reference points for understanding precedence logic traces and determining the completeness of the planning.

Things to Avoid

Program milestones and toll-gate milestones should not be used to represent actual work. Milestones are only reference points used to monitor a program's progress.

Applying soft constraints that impact the backwards pass to milestones without a solid understanding of the scheduling tools business rules, could result in a misrepresentation of task priority and misunderstood impacts to the schedule calculations.

Related Topics

Relationships / Logic
Task Constraints
Interface Hand-off Milestones
Horizontal Traceability
Vertical Integration and Traceability

5.7 Summaries and Hammocks

Manager's View

Summary and hammock tasks are both schedule elements designed to represent a roll-up/summary of lower level tasks. If used carefully, these elements provide a very useful capability to communicate the same program schedule data at a very detailed level or at a summary level (for example, for program management use).

Note: The business rules around these elements vary between the different scheduling software tools. Schedule management teams need to ensure they understand these rules in order to avoid unintended results in the IMS.

Description

Summary Tasks

Summary tasks represent a collection of schedule information on a group of tasks including but not limited to labor hours, cost, and dates. Typically, summary tasks represent a group of tasks that are located in the same physical location within the IMS or are part of the same parent Work Breakdown Structure (WBS) element. The methods for establishing summary tasks vary by tool.

Hammock Tasks

Hammock tasks represent a roll-up or summary of schedule information on a group of tasks including dates. Hammock tasks can represent any group of tasks in the IMS regardless of their physical location or parent Work Breakdown Structure (WBS) element. The methods for establishing hammock tasks vary by tool and are dependent on supporting task logic. (Note: not all tools support effective use of Hammock tasks.)

Examples

Summary Task

Task Name	Duration	Early Start	Early Finish	Late Start	Late Finish	Work	Cost
Summary Example	90 days	1/11	5/13	2/22	6/24	208 hrs	$20,800
Pre-Flight Activities	**60 days**	**1/11**	**4/1**	**2/22**	**5/13**	**192 hrs**	**$19,200**
Conduct Product Environmental Testing	40 days	1/11	3/4	2/22	4/15	160 hrs	$16,000
Hold Flight Test Readiness Review	20 days	3/7	4/1	4/18	5/13	32 hrs	$3,200
Flight Activities	**30 days**	**4/4**	**5/13**	**5/16**	**6/24**	**16 hrs**	**$1,600**
Perform Test Flight	30 days	4/4	5/13	5/16	6/24	16 hrs	$1,600
Test Flight Completed	0 days	5/13	5/13	6/24	6/24	0 hrs	$0

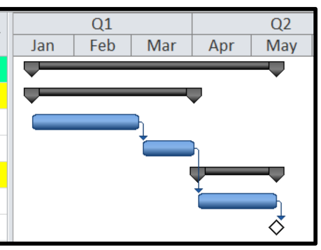


Figure 5.7-1 Example of a Summary Task in the IMS

In this example (Figure 5.7-1), 'Pre-Flight Activities' and 'Flight Activities' are Summary Tasks which roll-up dates, labor hours and costs of the tasks below.

Hammock Task

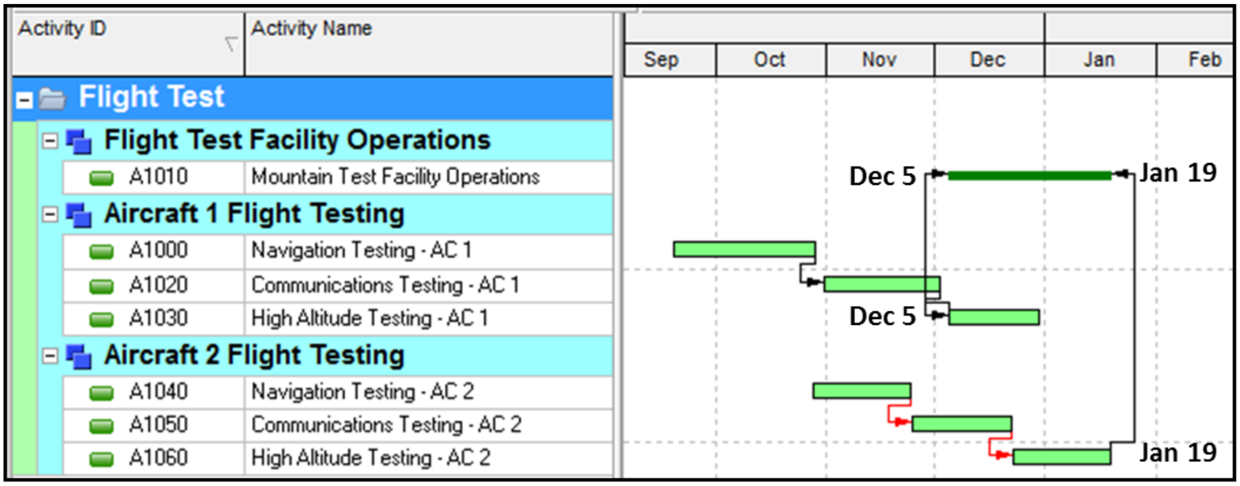


Figure 5.7-2 Example of a Hammock task in an IMS

In this example (Figure 5.7-2), 'Mountain Test Facility Operations' is a Hammock Task which rolls-up the dates of the assigned "high altitude" flight test tasks in the IMS, all of which may have different Control Accounts.

Calculations

Summary tasks roll-up duration, dates, labor hours, and costs.

Hammock tasks roll-up duration and dates. In some software tools, Hammock tasks can roll-up additional information about the tasks they are summarizing.

Things to Promote

Understand the business rules of your schedule software tool before attempting to resource load to Summary or Hammock tasks.

Things to Avoid

Use care when creating Hammock tasks as it is possible to introduce error if:

1. The underlying logic between the tasks is missing.
2. Changes to start or finish logic to the hammock, either through status updates or schedule execution, may impact the validity of the Hammock or the schedule itself.

Avoid assigning logical relationships to Summary tasks as this could potentially conflict with the detail schedule relationships under them causing confusion or circular logic.

Hammocks, by definition, should not drive successor logic. Hammocks collect the summarized baseline/forecast finish dates of the tasking in the measurement.

Related Topics

Relationships / Logic
Task Duration
Schedule Hierarchy
Vertical Integration and Traceability

5.8 Level of Effort (LOE)

Manager's View

LOE activities are those tasks defined as being of a general or supportive nature and having no measurable output, product or activities for which the attempt to measure progress would be value-added. It is important to ensure that discrete work is not planned as LOE, which earns schedule performance in alignment with the baseline, as it could result in an invalid impact to the IMS model calculations. LOE tasking can be included or excluded from the IMS model as appropriate. However, if LOE tasking is included in the IMS it should be separately identifiable and not affect the critical path.

Description

Level of effort tasking allows for an allocation of budget across the program period of performance to manage efforts with no measurable output, product, or activity. Schedule performance on these tasks is earned with the passage of time in alignment with the baseline distribution. There can be no schedule variances on LOE tasking.

There are pros and cons around including or excluding LOE tasking in the IMS. Including LOE tasking in the IMS allows for a more inclusive total program look at resource distribution, which aids in the maintenance and analysis of program resource distribution. However, if modeled incorrectly, including LOE tasking in the IMS can cause inaccurate total float and critical path calculations.

Optional Techniques

Consider not adding relationships to LOE tasks. As LOE tasks should never drive discrete work, programs may consider removing all logical relationships after the Performance Measurement Baseline is established, alternatively using soft constraints (i.e., Start No Earlier Than) in their place to peg the start to the correct timeframe. If used in this way, the constraint date and durations of the task should be consistent with the baseline Start and baseline duration.

Things to Promote

Tasks planned as LOE in the IMS should be easily and accurately identifiable. This includes populating the appropriate Earned Value Technique field (as applicable) and possibly even identifying the task as LOE in the task description.

During schedule baseline changes (i.e. a re-plan) ensure that you consider the impact of the schedule baseline change on the Level of Effort tasking. As the distribution of resources on these tasks will likely be impacted by the change and are often overlooked.

Resource distribution across an LOE task should be in alignment with the program needs and resource availability and not necessarily simply level loaded.

Consider adding an LOE Completion Milestone to tie all LOE tasking to the end of the program.

Ensure that task owners can demonstrate how the time phasing of their LOE tasking relate to the baseline program master schedule.

Ensure the LOE dates are forecasted to model the current estimated execution plan to ensure that ETCs and manpower spreads are realistic. The baseline for LOE tasks should be updated as necessary in accordance with the change control process.

Things to Avoid

LOE tasks should not be networked so that they impact discrete tasks. Incorrect logic application on LOE can lead to invalid impacts to the program critical path.

Level of Effort tasks should never appear on the critical path.

Related Topics

Horizontal Traceability
Vertical Integration and Traceability
Milestones
Intro to Cost/Schedule Resource Integration
Relationships / Logic

5.9 Apportioned Effort

Manager's View

The term "Apportioned Effort" is an Earned Value term used to categorize the relationship between a "base" program task or group of tasks and a related "support" effort. Programs can utilize the Apportioned Effort Earned Value Method (EVM) on a "support" task whose performance is always directly proportionate to that of its "base". Similar to Level of Effort tasks, Apportioned Effort tasks are not required to be in the IMS, but can provide value to the IMS, especially in the area of resource analysis.

Description

Apportioned Effort tasks have a direct association with the accomplishment of one or more discrete work packages. As such, an Apportioned Effort task will derive its time-phasing and percent complete from the task(s) to which it is associated. Including Apportioned Effort tasking may increase the complexity of an IMS. In addition, the methods used to model Apportioned Effort tasking vary widely from tool to tool. It is important to have a well thought out and consistent process in place when utilizing Apportioned Effort in the IMS.

There are two recommended methodologies for capturing Apportioned Effort tasking in the IMS:

1. Use a Hammock task to represent the "support" Apportioned Effort. In this scenario the Hammock task rolls up or summarizes the status and performance of the "base" task or tasks. (Note: not all tools support effective use of Hammock tasks)
2. Use a normal task to represent the "support" Apportioned Effort. In this scenario the "support" task is a Start-to-Start Successor of the earliest "base" task. The remaining logic, status, and performance of the "support" task are then manually aligned to match the status and performance of the "base" task or tasks during each status cycle.

Examples

A few of examples of Apportioned Effort include:

- Quality Control inspections (support) on fabrication efforts (base).
- In-process SW verification testing (support) on software engineering and design efforts (base).

Thing to Promote

Ensure the status on Apportioned Effort tasking (i.e. "support") always mirrors the status of the "base" tasking.

Document the program's Apportioned Effort methodology in the IMS Supplemental guidance.

Ensure that all relevant government and contractor stakeholders understand the program's Apportioned Effort methodology.

Ensure the Program Controls team understands in detail how Apportioned Effort tasking is managed in the respective scheduling and earned value tools and systems.

Thing to Avoid

Apportioned Effort tasking cannot drive or force a critical or driving path but may coincide on the critical or driving path along with its associated base task.

Related Topics

Horizontal Traceability
Vertical Integration and Traceability
Baseline Change Management

5.10 Working Calendars

Manager's View

Calendars specify when work on a program can and cannot be done by identifying the work hours for each workday, the workdays for each week, and exceptions, such as holidays. Calendars present the available work periods, working days and times of the day that tasks can use to determine start and finish dates based on the task duration and resource load where applicable. Calendars may be established for programs, tasks, and resources, and may be applied to leads and lags, depending on the scheduling tool. Calendars are of significant importance to program managers because schedules will incorrectly represent forecasted work if calendars are used inappropriately.

Description

Project Calendars

Project calendars identify working days and hours for entire programs and usually represent a program's typical schedule. Non-working days, such as company holidays, should be specified. In addition, other nonworking times may be identified to reflect periods when the entire team will be working on non-program activities, such as company meetings.

Task Calendars

Task calendars define the working and nonworking days and times for tasks. A single calendar may be applied to all the tasks in a program or customized calendars may be applied to specific tasks that will not follow the default work schedule, such as working 24 hours a day for seven days a week on testing tasks.

Resource Calendars

Resource calendars ensure that work resources (people and equipment) are scheduled only when they are available for work. They affect a specific resource or category of resources and can be customized to show individual schedule information, such as vacations, leaves of absence or equipment maintenance time and indicate the quantity of specific resources available as a function of time.

Calendars may be assigned using default calendars or custom calendars.

Default Calendars

Default calendars define the usual working and nonworking periods for tasks or resources. Examples of nonworking periods include lunch breaks and weekends. Most tasks use the default program calendar to determine their start and finish dates. A program calendar is typically based on an eight-hour workday, Monday through Friday, 40-hour workweek, and recognizes company holidays as non-workdays. However, some programs have special work schedules, such as a four-day work week, which may be chosen as the default calendar.

Customized Calendars

Customized calendars are unique calendars representing conditions identifying workdays and hours that are different from the default standard calendar to more accurately reflect available working and nonworking periods for these circumstances. They determine how tasks and resources are scheduled regarding these specific conditions. For example, customized calendars may reflect working Saturdays for the next two months or working two ten-hour shifts, seven days per week for a focused period. In addition, holidays may vary widely between a program team comprised of multiple companies or contractors that need to be identified using customized calendars.

Multiple Calendars

It is important to address the pros and cons of using a single calendar versus using multiple calendars.

- *Single file with multiple calendars*

  Be advised that applying different calendars to tasks in the same schedule may result in some date and duration calculations providing mixed values and making analysis more complex. For example, tasks with different calendars that are on the same logical path, in most cases, will have different total float values. Tasks using a five workdays per week calendar might have negative five days of total float and tasks using a seven workdays per week calendar might have seven days of negative total float. Both sets of tasks have one week of negative total float when measured against their respective calendars.

  Note: Ensure that the schedule management team understands the software tool's business rules around working calendars. This is because there is an order of precedence in place in regard to multiple calendars. Typically, the order of precedence is:

  #1. Program Calendar

  #2. Task Calendar

  #3. Resource Calendar

- *Multiple schedule files being consolidated into a single schedule*

  While adding precision to the IMS, there is added complexity that needs to be addressed and attended to when consolidating multiple schedule files into a single file. The individual responsible for consolidation should be aware of the different calendars in use and determine how to best integrate these.

Calculations

Tasks with durations and logic translate into dates based on the calendars that provide the dates that are available for scheduling. Milestones are zero based points in time, determined by precedence logic and / or constraints and utilize applicable calendars to reflect their dates and related time-based calculated values. When using durations, other than elapsed durations, only working days are used to populate start and finish dates based on their assigned calendars. Elapsed durations ignore the calendar's non-working days and populate start and finish dates based on both working and non-working days.

All time-based calculations use applicable calendars in determining their related values. These data items include start, finish, early start, early finish, late start, late finish, baseline start, baseline finish, actual start, actual finish, free float, total float, start variance, finish variance, and resource related work, assignment allocation, and delay fields.

Calendars used in different time zones may also cause issues and need to be resolved. This condition may exist when performing work at different geographical locations.

Optional Techniques

All tasks and milestones need a calendar assigned but the number and complexity of calendars used in a schedule is discretionary.

Things to Promote

Review and validate calendars on a regular basis to ensure accuracy.

Ensure configuration control is in place to avoid problems that can occur if calendars are not carefully managed. Otherwise, date and duration calculations could be incorrect.

Use calendars as part of what-if scenario techniques.

Include calendar definitions in the IMS Supplemental Guidance.

Have calendars available in a format that is accessible and readable by all program personnel (i.e., a spreadsheet). The added benefit of maintaining calendars in a spreadsheet in similar format is that it simplifies the import of calendar information into schedule software tools.

Ensure that the IMS uses the appropriate calendars to cover all of the program needs.

Things to Avoid

The complexity and number of calendars should not exceed the program's knowledge or ability to properly manage and validate the use of calendars.

Related Topics

Relationships / Logic
Task Duration
IMS Supplemental Guidance

5.11 Schedule Calculation Algorithm

Manager's View

The schedule calculation algorithm uses activity variables configured in the IMS model to calculate dates and float values. Your scheduling professionals should have a solid working knowledge of the algorithm to help facilitate schedule analysis.

Description

Scheduling tools calculate activity date and float values based on an algorithm that progresses forward and backward through the IMS network, applying stepwise calculations as it moved through the network. The algorithm takes into consideration the following variables in its calculations:

- Calendars (project, task, and resource non-working day calendars)
- Logical Relationships (i.e. Predecessors and Successors)
- Lag and Lead (i.e. negative lag)
- Activity Duration
- Activity Constraints
- Time Now (in scheduling software tools that enforce Time Now)

Calculations

Forward Pass: calculates the earliest possible Start and Finish Dates for every activity in the IMS network.

Backward Pass: calculates the latest possible Start and Finish Dates for every activity in the IMS network.

Total Float: the algorithm calculates total float by taking the delta between an activity's Late Finish Date and Early Finish Date (in workdays, based on the calendars applied to the task).

Free Float: calculated by taking the delta between an activity's Early Finish Date and Early Start Date of the earliest starting successor task of an activity.

Soft Constraints: allow the logic to drive the schedule (i.e. restricts only movement to the left) on the constrained task.

Hard Constraints: do not allow the logic to drive the schedule (i.e. either restricts all movement or restricts movement to the right) on the constrained task.

Program, Task, and Resource Calendars: calendar changes affect both the forward and backward pass.

Examples

Here are a few representative examples (Figure 5.11-1 through 5.11-4) showing how different schedule variables have an impact to the schedule calculation algorithm.

Task Name	Duration	Constraint Type	Constraint Date	Deadline	Task Calendar	Early Start	Early Finish	Late Start	Late Finish	Total Slack
Soft Constraint (Deadline)	**15 days**	**As Soon As Possible**	**NA**	**NA**	**Standard**	**1/11**	**1/29**	**1/7**	**1/27**	**-2 days**
Task A	6 days	As Soon As Possible	NA	NA	Standard	1/11	1/18	1/7	1/14	-2 days
Task B	7 days	As Soon As Possible	NA	NA	Standard	1/19	1/27	1/15	1/25	-2 days
Task C	6 days	As Soon As Possible	NA	NA	Standard	1/19	1/26	1/18	1/25	-1 day
Tack D	2 days	As Soon As Possible	NA	NA	Standard	1/28	1/29	1/26	1/27	-2 days
Project Complete	0 days	As Soon As Possible	NA	1/27	Standard	1/29	1/29	1/27	1/27	-2 days

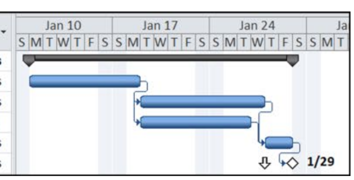


Figure5.11-1 Example demonstrating the impact of a Deadline in a schedule

In the scenario above (Figure 5.11-1), a deadline is used to apply an impact to the backwards pass while allowing the schedule to accurately project forecast dates.

Task Name	Duration	Constraint Type	Constraint Date	Deadline	Task Calendar	Early Start	Early Finish	Late Start	Late Finish	Total Slack
Hard Constraint	**15 days**	**As Soon As Possible**	**NA**	**NA**	**Standard**	**1/11**	**1/29**	**1/7**	**1/27**	**-2 days**
Task A	6 days	As Soon As Possible	NA	NA	Standard	1/11	1/18	1/7	1/14	-2 days
Task B	7 days	As Soon As Possible	NA	NA	Standard	1/19	1/27	1/15	1/25	-2 days
Task C	6 days	As Soon As Possible	NA	NA	Standard	1/19	1/26	1/18	1/25	-1 day
Tack D	2 days	As Soon As Possible	NA	NA	Standard	1/28	1/29	1/26	1/27	-2 days
Project Complete	0 days	Must Finish On	1/27	NA	Standard	1/27	1/27	1/27	1/27	-2 days

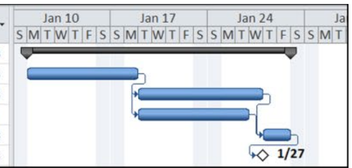


Figure5.11-2 Example demonstrating the impact of a Must Finish On Date Constraint in a schedule

In the scenario above (Figure 5.11-2), a Must Finish On constraint (considered a Hard Constraint) is used which has an impact on both the forward pass (i.e. Early Dates) and the backward pass (i.e. Late Dates).

Task Name	Duration	Constraint Type	Constraint Date	Deadline	Task Calendar	Early Start	Early Finish	Late Start	Late Finish	Total Slack
Calendars	**13 days**	**As Soon As Possible**	**NA**	**NA**	**Standard**	**1/11**	**1/27**	**1/12**	**1/27**	**0 days**
Task A	6 days	As Soon As Possible	NA	NA	7-Day Week	1/11	1/16	1/12	1/17	1 day
Task B	7 days	As Soon As Possible	NA	NA	7-Day Week	1/17	1/23	1/19	1/25	2 days
Task C	6 days	As Soon As Possible	NA	NA	Standard	1/18	1/25	1/18	1/25	0 days
Tack D	2 days	As Soon As Possible	NA	NA	Standard	1/26	1/27	1/26	1/27	0 days
Project Complete	0 days	As Soon As Possible	NA	NA	Standard	1/27	1/27	1/27	1/27	0 days

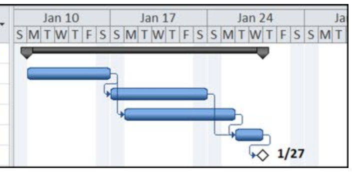


Figure 5.11-3 Example demonstrating the impact of changing the Task Calendar on date calculations

In the scenario above (Figure 5.11-3), changing the Task Calendar will have an impact on both the forward pass (i.e. Early Dates) and the backward pass (i.e. Late Dates).

Task Name	Duration	Predecessors	Task Calendar	Early Start	Early Finish	Late Start	Late Finish	Total Slack
Lags	**19 days**		**Standard**	**1/11**	**2/4**	**1/11**	**2/4**	**0 days**
Task A	6 days		Standard	1/11	1/18	1/11	1/18	0 days
Task B	7 days	2	Standard	1/19	1/27	1/25	2/2	4 days
Task C	6 days	2	Standard	1/19	1/26	1/19	1/26	0 days
Tack D	2 days	4FS+5 days 3	Standard	2/3	2/4	2/3	2/4	0 days
Project Complete	0 days	5	Standard	2/4	2/4	2/4	2/4	0 days

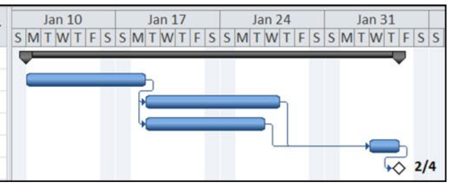


Figure 5.11-4 Example demonstrating the impact a Lag on the Forward and Backward Pass

In the scenario above (Figure5.11-4), a Lag is used which has an impact on both the forward pass (i.e. Early Dates) and the backward pass (i.e. Late Dates).

Things to Promote

Each scheduling software tool has different configuration options that can alter the way the schedule algorithm uses the variables to calculate dates and float. Ensure that you understand the impact of these configurations and that their application is consistently applied.

Related Topics

- [Statusing to Time Now]
- [Forecasting]
- [Managing using the IMS]
- [Intro to Schedule Execution Metrics]

5.12 Schedule Margin

Manager's View

There is an increased emphasis on execution to schedule resulting from both the government's initiatives on affordability and the overall changing economic climate. As such, program management teams are expected to deliver their programs on time, on target, and on cost. One optional technique available to these program management teams is the establishment of schedule margin within the IMS. Program teams can establish schedule margin by inserting a task(s) to represent the time necessary to account for estimated schedule risks/uncertainties. By accounting for schedule risk/uncertainty, the goal is to increase the accuracy of downstream forecasts.

Schedule margin is owned and controlled by the Program Manager. For clarification, it should be understood that schedule slack (float), which is a calculated value based on network logic (i.e.; task durations, relationships, constraints, lags, leads, etc.), should not be considered as schedule margin. Schedule margin is a separately planned quantity of time above the planned duration estimate reflected in the IMS.

Description

Program teams should follow the following guidelines when using Schedule Margin:

- Schedule Margin should be represented in both the Baseline and Forecast schedules
- Schedule Margin tasks should be restricted to an appropriate number of occurrences based on managing risk to increase schedule accuracy
- Schedule Margin duration should be the Program Manager's assessment of the amount of remaining schedule risk/uncertainty to the subsequent event
- Schedule Margin duration should be justifiable and traceable to the program's risk management system
- Schedule Margin tasks should be clearly and consistently identifiable
- Schedule Margin should be placed as the last task/activity before key contractual events, significant logical integration/test milestones, end item deliverables, or contract completion

Things to Promote

Ensure that Schedule Margin tasks/activities are taken into consideration during resource, staffing, and EAC planning.

Ensure that the impact of Schedule Margin tasks/activities is taken into consideration when executing to and analyzing the program IMS.

Zero out all durations on Schedule Margin tasks during Schedule Risk Assessments.

Ensure there is a comprehensive and well understood process for managing Schedule Margin that is understood by all applicable members of the government and contractor program teams.

Ensure that the Schedule Margin management process and rationale for Schedule Margin durations are documented in the IMS Supplemental Guidance.

While Schedule Margin duration will generally decrease over time as risks/uncertainties diminish, it is possible for the duration to increase as additional risks and uncertainties are discovered.

An SRA can be used to estimate the risk/uncertainty remaining to a deliverable milestone, and thus the duration of a Schedule Margin task. For example, if the Program Manager would like to forecast a deliverable date with at least 50% confidence, the Schedule Margin duration could be set to the difference (in working days) between the current forecast date in the IMS and the P50 date from the SRA.

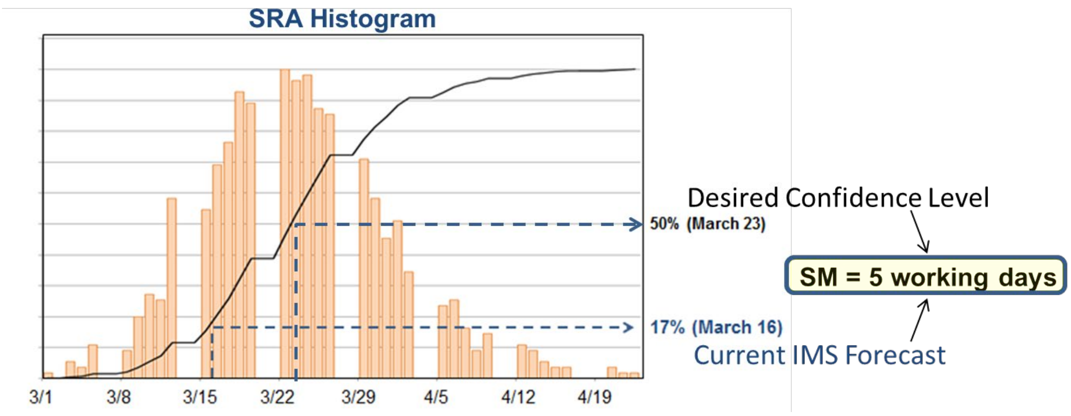


Figure 5.12-1 Using SRA results to quantify Schedule Margin Duration

Things to Avoid

Avoid abandoning the concept of using Schedule Margin in an Over Target Schedule (OTS) scenario. It is equally applicable in both normal program execution and OTS situations.

Avoid using Schedule Margin durations to hold a deliverable forecast to a static date. Schedule Margin should be based upon risks and uncertainties and not managerial goals.

Related Topics

Managing Using the IMS
Schedule Acceleration Techniques
Baseline Change Management
Schedule Baseline v. Forecast
Schedule Risk Assessment (SRA) - Setup and Execution

6 Cost and Schedule Resource Integration

This section contains the following chapters.

6.1 Intro to Cost/Schedule Resource Integration

The following chapters define methods of handling resources as they relate to the IMS. The content includes an explanation of maintaining resources in an IMS using both native fields (i.e. scheduling tool's standard resource fields) and static/non-native fields (i.e. static, fields defined by the user). Additionally, a third method of handling resources outside of the IMS, by maintaining traceability and integration via external tools and processes, is discussed.

This guide recommends the following order of preference between the different methods of handling resources as they relate to the IMS:

1. Resources in the Schedule (native field method)
2. Resources in the Schedule (static/non-native field method)
3. Resources not in the Schedule

This order of preference is based on the inherent value that carrying resources within the IMS brings to IMS update, maintenance and analysis, activity ownership, and cost/schedule integration. However, this order of preference in no way implies a lack of compliance or capability with any of the aforementioned methods.

In all three methods, to ensure Cost/Schedule integration, dates from the IMS should be imported into the cost tool.

6.2 Resources in the Schedule

Manager's View

Cost/schedule integration is a process that links cost and schedule system data to ensure traceability and consistency between the systems. Cost/schedule integration is a key factor to program success as it helps to ensure reporting of consistent and accurate program performance, including EV Metrics and program forecasts. Additionally, maintaining resources in the schedule helps the program team reconcile staffing requirements and ensure that all work is accounted for in the IMS.

The key components to cost/schedule integration are:

1. Time phasing of BCWS in the cost system is within the baseline period of performance (baseline start and baseline finish dates) in the IMS for the applicable Control Accounts, Work Packages, and Planning Packages.
2. Earned Value (BCWP) performance claimed and the ETC (Estimate to Complete) period of performance is traceable between the IMS and the cost system.
3. Resource categories and quantities match between the IMS and the cost system (when resources are maintained in the IMS).

Description

Maintaining resources in the IMS is recommended, but not required. It enhances the ability to more accurately model the program's forecast and increases the analysis capability of the IMS. This includes the ability to quickly compare task duration and related resource requirements (including skill mix and quantity) to validate task achievability. Resource visibility also provides insight to the amount of resources required to complete a task. This gives insight to each task's significance in comparison to the other tasks in the IMS. When resources are physically maintained in the IMS, it can serve as a single control point for cost/schedule integration. Additionally, it enables the automation of data transfer from scheduling systems to EVM Systems which eliminates redundant effort and/or human error in the data transfer.

Native Field Method

This method of resource loading uses native schedule fields to capture and time phase resource information. The resource pool defined in the scheduling system contains descriptive information for each resource. The quantity of resources is defined when resources are assigned to schedule activities. Resources defined to an appropriate category level provide insight for available skill-related quantities. The scheduling system time phases the quantity of resources based on user input (level spread, curve codes, delays, or manual phasing).

This approach streamlines the resource loading process by eliminating the need for additional software tools and/or manual processes to time phase resource quantities.

Analysis benefits of this method include:

- Integrated capability to validate potential impacts or opportunities of resource availability on the schedule
- Staffing profiles are easily generated from the scheduling tool for all or portions of the program plan
- Real time resource alignment for recovery or what-if schedule modeling is available (existing resource time phasing moves with the schedule activities)

Note: Programs should ensure they understand the implications on cost/schedule integration due to potential differences in start/end dates between IMS monthly calendars and fiscal calendars utilized in EVM Systems. If the scale of the data in the IMS is not equivalent or relatable to fiscal months, then an accurate comparison of time phased data between the IMS and cost system cannot be performed. However, if resources are loaded at the work package level in the IMS, then the work package totals in the IMS should reconcile with the work packages totals in the cost system.

Static/Non-Native Field Method

This method of resource integration uses static fields that are defined by the user (text, number, or other fields) to capture resource information (both description and quantity) for each task. Resource quantities are time phased outside of the scheduling system; the time phasing is still required to be aligned with the schedule dates. This method separates the resource calculations from the schedule date calculations in the scheduling tool.

The benefit of using this method versus not maintaining resources in the schedule is that some, albeit limited, resource information is available in the IMS for analysis of potential impacts or opportunities and does provide a degree of magnitude visibility for tasks.

The disadvantage of this method is the required use of additional software tools and/or manual processes to time phase resource quantities and additional verification steps to ensure cost/schedule integration.

Note: As this method provides only rudimentary cost/schedule integration analysis, it is not considered resource loading by all customers.

Examples

Native Field Method

Typical fields include:

- Resource Name
- Non-Labor Costs (i.e. Material or ODC) - Optional
- Work in Hours
- Start and Finish (Baseline and Early Dates)

Control Account	Task Name	Resource Names	Work (labor)	Cost (non-labor)	Start	Finish	Baseline Start	Baseline Finish
01.OA.02	Generate Draft System Reqs Doc	Systems Engineer	176 hrs	$0	1/18	2/16	1/11	1/18
01.OA.02	Conduct Internel Review of Systems Reqs Doc	Sr. Systems Engineer	16 hrs	$0	2/17	2/18	1/19	1/27
01.BA.11	Procure Midwing Casting	Material[1]	0 hrs	$23,000	2/17	2/24	1/19	1/26

Figure 6.2-1 IMS Resource Example from Native Field Method

	Resource Name	Baseline Work	Remaining Work	Details	May	Jun	Jul	Aug	Sep	Oct
	+ Unassigned	0 h	0 h	Base. Work						
1	+ SrSystemEng	560 h	400 h	Base. Work		208h	272h	16h	64h	
2	+ SwEng2	120 h	120 h	Base. Work				120h		
3	+ SwEng1	80 h	80 h	Base. Work				56h	24h	

Figure 6.2-2 Baseline Staffing Profile View Example from Native Field Method

Static/Non-Native Field Method

Typical fields include:

- Resource Name
- Non-Labor Costs (i.e. Material or ODC) - Optional
- Work in Hours

Control Account	Task Name	Resource Name (Text10)	Work Hrs (Number10)	Cost ($) (Number11)	Start	Finish	Baseline Start	Baseline Finish
01.OA.02	Generate Draft System Reqs Doc	Systems Engineer	176	0	1/18	2/16	1/11	1/18
01.OA.02	Conduct Internel Review of Systems Reqs Doc	Sr. Systems Engineer	16	0	2/17	2/18	1/19	1/27
01.BA.11	Procure Midwing Casting	Material	0	23000	2/17	2/24	1/19	1/26

Figure 6.2-3 IMS Resource Example from Static/Non-Native Field Method

Category	Native Method	Static/Non-Native Method
Resource Graphs	Yes	No
Resource Time Phasing	Yes	No
Duration v. Resource Comparison (Task Level)	Yes	Yes
IMS v. Cost System Resource Comparison	Yes	Yes

Figure 6.2-4 Comparison resource analyses available in the IMS (native v. static)

Calculation

Native Field Method

The fundamental calculation for most scheduling tools uses the same base components: activity duration, total resource quantity, and incremental quantity (time phasing) calculated against an identified calendar (task or resource). The specific implementation in each scheduling tool and calculation implications are different. It is important that the resource calculation related business rules and settings used in each scheduling application are understood and applied appropriately at the task and resource levels.

Static/Non-Native Field Method

As this method captures resource information in static fields, it does not utilize any resource calculations in the schedule tool.

Things to Promote

Include both labor (hours) and non-labor elements (unburdened costs) in resource planning. This allows managers to compare labor/cost reports from the IMS, which are typically available earlier than cost reports, and make better informed decisions.

Align resource requirements with resource availability to assure an achievable schedule.

Ensure that Estimates to Complete (ETC) are consistent with the forecasted IMS. This will require manual assessment and adjustments if using the static/non-native method because the static fields will not update as the forecast schedule changes.

Use the same non-working calendar (holidays and weekends) in the IMS and the cost system to ensure traceability between the systems.

Ensure that the program uses a consistent planning and resourcing approach for ODC, material and LOE tasking.

In the native field method, if BCWS is captured in the baseline IMS, the BCWS spread should align between the cost and schedule systems if both systems are using the same fiscal and manpower calendar.

The resource pool should be designed prior to program planning to ensure adequate level of detail for the program is available and consistent across the program.

Ensure alignment between the resource quantity and schedule duration to enable proper resource allocation. For example, resource requirements are substantially different for 2 engineers for 10 days opposed to 10 engineers for 2 days even though the hours are 20 in both cases.

Things to Avoid

Avoid updating the resource assignments directly in the cost tool. Resources assignments should be updated in the IMS and then imported into the cost tool.

Redundant and unused resources in the resource pool will complicate resource planning and de-confliction in the native field method.

When planning, take care when using logic to resolve resource conflicts. Using logic to model resource constraints can over complicate the schedule network, especially if the resource relationships are not thoroughly documented. Scheduling systems typically provide alternate methods to represent resource constraints, such as a Leveling Delay or the use of constraints impacting the early dates.

Avoid planning resources on schedule milestones (zero-day duration). Scheduling systems may or may not prevent this. Resource efforts should only be planned and/or forecasted where time is planned and/or forecasted. Common pitfall to avoid is receipt of purchased material, when the receipt milestone (zero-day duration) activity contains the resource for material costs. These types of activities should be one day in duration to reflect the accrual of the material and to accommodate resource planning.

Avoid planning resources in the IMS by name. Although accurate it typically requires excessive maintenance to handle project staffing changes.

Use great care when transmitting schedule data to appropriately sanitize rates and factors from the IMS as necessary to protect proprietary information. Note: It is optional to include labor or material rates and factors in the IMS.

Mechanically, most scheduling software can accommodate summary level resource planning. However, if not carefully implemented, it may cause duplications in the resource plan. Resource planning on summary tasks may also complicate resource balancing and resource analysis.

Avoid over allocating personnel by assuming they can work on the program at full capacity (i.e. 8 hours/day) without considering things like vacation, sick time, and corporate training requirements.

Related Topics

Intro to Cost/Schedule Resource Integration
Resources Not in the Schedule
Working Calendars
Statusing to Time Now
Horizontal Traceability
Vertical Integration and Traceability

6.3 Resources Not in the Schedule

Manager's View

The Integrated Master Schedule (IMS) is an important element of a company's Cost/Schedule management process. Regardless of whether a schedule has resources included, it should facilitate resource analysis and drive resource needs and mitigations. In schedules without resources, the resource information is only physically contained native in the cost tool.

Description

When resources are not included in the schedule, resource quantities are time-phased outside of the scheduling system but must align with IMS dates. While personnel resources are not loaded into the IMS, resource planning is essential to the development of a credible, executable program plan. It is therefore important that the IMS and the Basis of Estimates (BOEs) be tightly coupled, during the proposal process, and the IMS and control account plans be tightly coupled during execution. The IMS provides the time phasing of tasks against which resources are planned. The program team needs to consistently review the BOEs and/or control account plans to ensure that this correlation is maintained, and it is recommended the IMS dates are imported in the cost tool.

In non-resourced schedules, the IMS activities are mapped to the work package. This is accomplished by establishing a field in the IMS with identifiers for each task so that it is relatable to the work package. As the resources are not resident within the IMS it is necessary to look outside of the scheduling system to ensure an appropriate time-phased workload.

Note: When using a schedule without resources, you can still maintain a system where cost and schedule is integrated. However, the ability to use the IMS as the standalone, interactive tool for resource analysis is diminished.

Example

Integrated Master Schedule

Work Package	Task Name	Duration	Start	Finish	Baseline Start	Baseline Finish
01.OA.02-01	Generate Draft System Reqs Doc	22 days	1/18	2/16	1/11	2/9
01.OA.02-02	Conduct Internal Review of Systems Reqs Doc	2 days	2/17	2/18	2/10	2/11
01.OA.02-03	Incorporate Internal Review Comments into System Reqs Doc	6 days	2/19	2/26	2/12	2/19
	Submit System Reqs Doc to Customer	0 days	2/26	2/26	2/19	2/19
	SVT - Customer Review of System Reqs Doc	45 days	2/29	4/29	2/22	4/22
01.OA.02-03	Incorporate Customer Comments into System Reqs Doc	10 days	5/2	5/13	4/25	5/6
	Submit Final System Reqs Doc	0 days	5/13	5/13	5/6	5/6

Cost System

Work Package	Task Name	Hours	BCWS	BCWP	ACWP	Resource	Start	Finish	Baseline Start	Baseline Finish
01.OA.02-01	Generate Draft System Reqs Doc	176	$ 21,120	$ 10,560	$ 9,856	Systems Engineer	18-Jan	16-Feb	11-Jan	9-Feb
01.OA.02-02	Conduct Internal Review of Systems Reqs Doc	16	$ 2,400			Sr. Systems Engineer	17-Feb	18-Feb	10-Feb	11-Feb
01.OA.02-03	Incorporate Internal Review Comments into System Reqs Doc	40	$ 4,800			Systems Engineer	19-Feb	26-Feb	12-Feb	19-Feb
01.OA.02-03	Incorporate Customer Comments into System Reqs Doc	40	$ 6,000			Sr. Systems Engineer	2-May	13-May	25-Apr	6-May

Figure 6.3-1 Resources not in the IMS, example IMS with Work Package identifiers

Things to Promote

Continual monitoring to ensure tight coupling of IMS tasks and work packages is maintained.

Continual evaluation of resources planning changes for potential impact to IMS credibility.

Ensure that Latest Revised Estimates (LRE) and Estimates to Complete (ETC) are consistent with the forecasted IMS.

Things to Avoid

Manual processes for time phasing of resource quantities and verification of cost schedule integration as it is prone to human error.

Related Topics

Intro to Cost/Schedule Resource Integration
Resources Not in the Schedule
Working Calendars
Statusing to Time Now
Horizontal Traceability
Vertical Integration and Traceability

7 External Schedule Integration

This section contains the following chapters.

7.1 Subproject/External Schedule Integration

Manager's View

Some Program Integrated Master Schedules consist of multiple stand-alone IMS components, integrated to represent the total work scope of a program effort. These components typically consist of the prime contractor (i.e. the company holding the original contract award from the customer) schedules, as well as customer or subcontractor schedules. Together, these schedules represent the total amount of work scope for the program, including the associated risks and opportunities.

To ensure that the IMS provides program management with a comprehensive view of the remaining work and an accurate assessment of current schedule performance, programs can integrate external schedules into the detailed IMS. The approach depends on complexity and risks associated with the external effort. Creating tasks to represent the external work or including interface milestones may be appropriate in situations where the risk or complexity is low. However, integrating the external schedule in its entirety is the most comprehensive approach and may be more suitable for high risk or complex schedules. Regardless of method employed, accurate, timely schedule data reflecting relationships between supplier and prime tasks, ensure the necessary visibility to all stakeholders.

Description

Integration of external schedules in their entirety requires a disciplined process between the organizations involved to ensure the seamless incorporation of the subcontractor and prime contractor schedules.

This process starts with the contractual flow down of detailed scheduling requirements to the subcontractor to ensure the following:

1. The data submitted is in an acceptable format and includes all necessary fields. Although it is not a requirement that a common scheduling tool be utilized, it is necessary to define the expected data fields, format, calendars, business rhythm, resourcing, and tool settings/options (as appropriate) to facilitate exporting and importing the schedule data between tools.
2. Preferably, status dates are consistent between the prime contractor and supplier schedules. If the subcontractor's schedule update is to a different point in time it could potentially affect the IMS analysis results. If it is not possible to have consistent status dates between the various schedule elements then implement, and ensure all parties support, a strict process of managing the impacts of the update differences.
3. Change control procedures are established and understood. The prime contractor should clearly communicate which type of schedule changes will require pre-approval before incorporation and which type will require coordination only or documentation upon submittal. The lack of a disciplined change control process can result in disconnects between the prime contractor and subcontractor's schedule.
4. Clearly communicate expectations regarding schedule quality to the subcontractor. In addition, implement a process for conducting quality checks prior to submittal to avoid rework and delays during the integration process.

If the prime and subcontractor are using a common scheduling tool, integrate the subcontractor's schedule by including their file in the master IMS. If using different tools integrate the subcontractor's schedule by exporting it to a data file and then importing it into the detailed IMS. Once the data is integrated, establish the relationships between the prime contractor and subcontractor schedules.

Warning: Each scheduling tool has different schedule calculation options and algorithms. This means that data imported from one tool will typically calculate differently in another tool. Understand and mitigate these differences to ensure the most accurate forecast model possible.

Validate the accuracy of the resulting IMS once the program completes the subcontractor integration process. This validation is most effective when conducted as a joint review with all parties. After establishing the accuracy of the fully integrated IMS, the normal assessment period analysis reveals potential schedule impacts and dictates recovery or work around plans.

Example

Section in RED represents a subcontractor IMS integrated into the Prime Contractor's schedule (Figure 7.1-1).

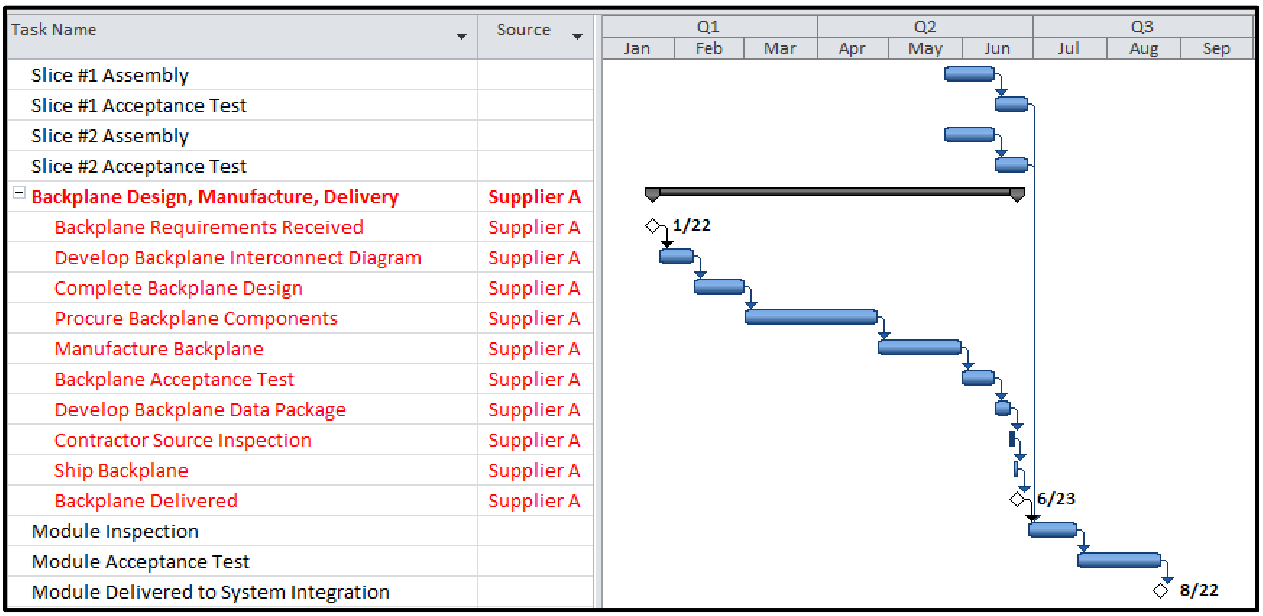


Figure 7.1-1 Example of a Subcontractor IMS embedded within a Program IMS

Optional Techniques

Use Interface milestones to represent interface points with the subcontractor's schedule. This approach is easier to implement and maintain but provides less insight into the subcontractor's current schedule performance. If used, this technique requires the manual update of each interface milestone to reflect the latest forecasted dates from the supplier's schedule. This approach yields the best results with less complex or lower risk suppliers.

Representative Model - at a level between integrating the entire supplier schedule into the prime IMS and using interface milestones, this approach requires a roll up or summarization (or representation) of the subcontractor's work being careful to retain required relationships to allow good critical path analysis.

Things to Promote

Contractual flow down of the scheduling requirements along with frequent and timely communication is necessary for a successful integration process.

Including the supplier in IMS review meetings and requiring them to address their schedule as integrated into the IMS will increase their awareness of any integration issues and encourage their buy-in of the process.

Consider integrating subcontractor schedules into the prime contractor's detailed IMS instead of using Interface Milestones as it results in a more complete program forecast upon which to conduct predictive analysis.

Where contractually possible, maintain that the program integrating the overall schedule, not the individual subproject, owns all Float or Slack.

Things to Avoid

Late deliveries of schedule data will affect the timing and quality of the program IMS.

Poor quality in the supplier schedule will negatively affect the program IMS. Incorporating quality checks into the submittal process can help minimize this risk.

An inadequate change control process or a large volume of changes can make it difficult and very time consuming to integrate the supplier's schedule.

Related Topics

Horizontal Traceability
Interface Hand-off Milestones
Statusing to Time Now
Forecasting
Schedule Visibility Tasks (SVT)

7.2 Interface Hand-off Milestones

Manager's View

The integration of external schedules (subs / suppliers / government items etc.) via interface Hand-off milestones into the program's IMS provides insight as to the relationship of an external performer to the overall program. This method ensures external impacts to the program are represented in the program IMS.

Description

External performers often introduce risk to programs. One method of providing visibility into the potential impact of external performer's schedules is by the use of Interface Handoff Milestones. These milestones typically represent a significant delivery or receipt-date. This type of integration is not ideal as it only allows for limited visibility to external schedules, but it is an expedient means by which managers can determine if issues exist.

Characteristics

1. Provides limited, but consistent visibility of impacts
2. Provides the ability to monitor challenges to supplier commitments
3. Allows for schedule integration
4. Does not allow for complete risk modeling
5. Only by analysis of the external performer's detailed IMS can schedule impacts be identified early. Monitoring of interface milestones will provide limited data and typically necessitate additional information to effectively mitigate problems.

Example

The following example (Figure 7.2-1) shows an Interface Hand-off Milestone identifying a Backplane Delivery from a supplier linked into the logic network. In this example, the start constraint on the Interface Hand-off Milestone would match the forecast finish date provided by the supplier (or in the best case, in the supplier's IMS). In this case, the supplier delivery would cause a break in the "Integration and Test" process and the management team would likely desire to work with the supplier to try and bring the delivery back to the left.

Interface Handoff	Task Name	Constraint Date
	PC Card #1 Assembly	NA
	PC Card #1 Acceptance Test	NA
	PC Card #2 Assembly	NA
	PC Card #2 Acceptance Test	NA
Backplane #9 Delivery	Receive Backplane #9	3/7
	Test 1 Module Integration	NA
	Test 1 Module Acceptance Test	NA
	Test 1 Module Delivered to SYSINT	NA

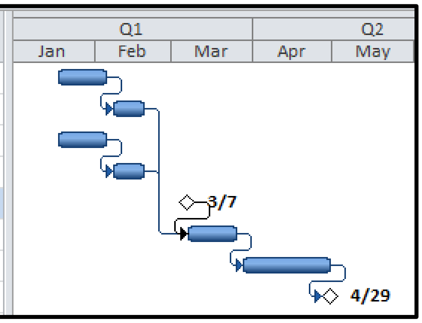


Figure 7.2-1 Example of an Interface Hand-off Milestone

Optional Techniques

Reference the Managing/Integrating External Schedules for alternative methods of representing external dependencies in the programs IMS model.

Things to Promote

Work with major subcontractors to coordinate the fidelity and frequency of schedule submittals. Once the schedules are integrated, feedback from the program detail schedule should be communicated back to all stakeholders (including subcontractors).

Ensure that the implications of Time Now misalignment between the program IMS and the external IMS are understood and mitigated.

Interface Hand-offs should not only represent external dependencies driven from external sources but also tie points from the program IMS to external sources.

When modeling Risk, consider a technique whereby the Interface Hand-off Milestone may be re-defined to a task with duration (temporarily) to capture the most likely/least likely durations (correlating to the most likely/least likely dates) for delivery of the item.

Typically, the Interface Hand-off Milestone represents deliveries from external sources. As such, programs should validate that the resulting delivery date, captured in the program IMS as an Interface Hand-off Milestone with a soft constraint Start Date, (i.e... Start No Earlier), is accurate and driven by sound logical relationships from the external sources' schedule.

Consider flagging/coding Interface Handoff Milestones to facilitate schedule maintenance and analysis.

Consider adding intelligence into the name/description and/or a code field for Interface Milestones. Examples of this could include pre-pending the name with REC (for receive milestones) or DEL (for delivery milestones) and EXT (for external outside the program team) or INT (for internal inside the program team).

Ensure the program's methodology of integrating external efforts into the IMS is consistent with contractual obligations.

Related Topics

Subproject/External Schedule Integration
Schedule Visibility Tasks (SVT)
Schedule Hierarchy

7.3 Schedule Visibility Tasks (SVT)

Manager's View

Schedule Visibility Tasks (SVTs) represent effort that is not part of the budgeted program scope, but that is related to and may potentially impact program tasks. By modeling these dependencies as tasks, SVTs may provide increased management visibility to items otherwise represented as lag or constrained milestones.

Description

Schedule Visibility Tasks (SVTs) are tasks/activities or milestones with no resources assigned. They are included in the IMS to increase the usefulness of the IMS and characterize potential impacts to the logic driven network. SVTs tend to fall into one of the following categories:

- Work, that is not part of the PMB, performed by an outside organization such as Government Furnished Equipment (GFE), Customer Furnished Equipment (CFE), review of submitted CDRL items per the contract, and subcontractor shipping spans
- Passage of time while no direct resources are expended such as "Scheduled Maintenance" times for equipment and "curing/drying" times

Note: Do not use SVTs as zero-budget work packages.

Example

The following example (Figure 7.3-1) shows an SVT used to capture work performed by the customer

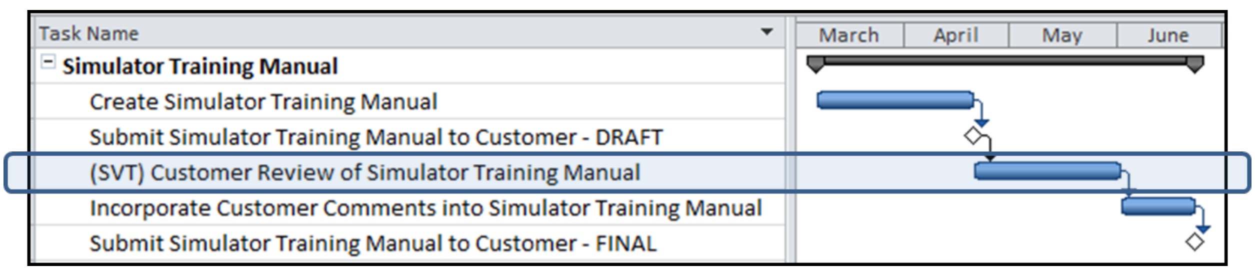


Figure 7.3-1 Example of the use of an SVT to capture Customer Review Time

Optional Techniques

An alternative to this type of task is the use of a lag to represent the equivalent elapsed time or an Interface Hand-off/drop milestone to represent an external dependency.   If the IMS uses lags or handoff milestones instead of SVTs, it is important to ensure that task owners validate their durations during each status period. Additionally, ensure that task owners appropriately document the lag in the IMS to support an increased understanding of the IMS workflow during schedule analysis.

Things to Promote

Clearly identify SVTs by using "SVT" in the name/description. Additionally, SVTs can be identified in a code field.

Ensure to deconflict with other usage of the acronym SVT, such as System Verification Test.

SVTs should have task owners and have their status updated at the same time, using the same process as other IMS activities.

Document the use of SVT tasking in the IMS Supplemental Guidance.

Things to Avoid

Avoid misuse to ensure proper status at necessary intervals. If mapped to control accounts or WBS elements, they may introduce discrepancies in the period of performance between the IMS and the Earned Value database, specifically if the task with no resources is at the beginning or end of the control account or WBS. SVT's are not part of the Performance Measurement Baseline (PMB).

Use care to avoid period of performance conflicts between the IMS and the Performance Measurement Baseline due to using SVT tasks. Document these effects such that they are explainable during audits.

Avoid misuse (i.e. designating a budgeted in-scope effort as an SVT task) and ensure proper status at necessary intervals.

Related Topics

Interface Hand-off Milestones
Horizontal Traceability
Subproject/External Schedule Integration

8 Horizontal and Vertical Traceability

This section contains the following chapters.

8.1 Horizontal Traceability

Manager's View

Horizontal traceability refers to the logical relationships and time-phasing between tasks and milestones from the project start to finish. It includes predecessor and successor relationships and "hand-offs" within and across the various schedule sections (e.g., control accounts, Integrated Product Teams, WBS elements, etc.). When a schedule is properly built and maintained, sound horizontal traceability helps the PM during execution to ensure schedule predictability for completing key deliverables and events.

Description

Horizontal traceability is the ability to trace the network logic from project start to finish through the IMS precedence or successor relationships. If the schedule can be traced horizontally, relationships are in place to determine the workflow and aid in assessing schedule impacts as work progresses and conditions change. Being horizontally traceable, however, is not a simple matter of making sure that each task has a predecessor and successor. Instead, tasks should be linked to their most appropriate predecessors and successors based on required inputs and outputs. Horizontal integration also demonstrates that the overall schedule is planned in a rational, logical sequence that accounts for interdependencies. At a minimum, the network logic includes all discrete work (including detailed tasks, work packages and planning packages) and provides a means for assessing interim progress and forecast completion through the key events, deliverables, and the program finish.

Benefits of networking

Effective horizontal traceability ensures that nothing in the schedule improperly restricts starts and finishes and that the entire network is constructed of logically tied and progress driven effort determining remaining duration.

Provides correct order of execution

A properly networked schedule reflects a logical flow of task execution to accomplish the technical work scope. This flow provides the basis for critical path analysis, a method for identifying and assessing schedule priorities and mitigating impacts.

Aids in predictability

The schedule's predictability is directly related to how complete and valid the network logic and duration estimates are in a schedule. Missing or incorrect logic ties increase the difficulty in assessing future performance in achieving key deliverables and target dates.

Linking within a Control Account

Control Accounts have identified, specific work products usually requiring a sequence of several related tasks to accomplish or deliver the products. Linking the tasks within a control account provides a logical sequence or workflow. Tasks dependent on another work product are linked as a successor to the appropriate related task. Control accounts have clear start and finish tasks or milestones that span the control account period of performance.

Linking between Control Accounts

Products accomplished in one control account often provide inputs or support to tasks in other control accounts (or other schedule sections). Since the network logic is developed at the task level, the predecessor task will be in one control account and the successor task will be in another control account thereby creating the hand-off dependency. Hand-off dependencies should be task-to-task. Consider a repeatable process for such linkage between control account tasks.

Program / Toll-gate Milestones

The predecessors of a Program Milestone should represent the inputs (detailed work or events) required to be completed prior to starting or finishing the milestone. The successors of a Program milestone should represent the outputs or detailed work that may start or finish only upon completion of the milestone.

At times, many detailed tasks may need to be linked to these Program milestones. To reduce the number of logic ties, "toll-gate" milestones may be used. These are milestones placed throughout the schedule in key points where a collection of tasks end and new work begins. Examples are creating a toll-gate milestone named "IPT X Ready for CDR" for each IPT that provides inputs to the CDR event. If there are five IPTs, then the five IPT toll-gate milestones are ultimately linked to the same CDR Conduct milestone or Event Milestone, thereby ensuring horizontal integration through CDR.

Identifying logic path that results in a product, deliverable or end item

Detailed tasks on the same logic path should represent the efforts required to achieve a certain product, deliverable or end item. Whenever possible, use current and repeatable logic block templates to help accelerate schedule development and to promote repeatable quality.

Reverse planning; an approach for ensuring horizontal integration

To ensure the correct tasks are linked to a product, deliverable, end item, or event, trace and validate the predecessors starting from the deliverable and following the predecessor path towards the beginning of the network path. In other words, start at the deliverable and work through the predecessor chain reviewing all the predecessors for accuracy. All the predecessor tasks should be delivering a work product that benefits the endpoint. Task holders should work with the Program Planner/Scheduler to delete any incorrect linkages and ensure that the tasks have the logic ties that are representative of the completion of the effort. Any delinked tasks must be checked to ensure that they have other predecessors and successors.

Review of logic

When the initial effort to establish all the relationships between tasks is completed, a review of the network logic is conducted until the program team agrees it is accurate. Revising logic is an iterative process, depending on how the logic is reviewed and agreed upon. Given that relationships often reach across areas of responsibility, changes to logic in one control account may affect the tasks in another control account and require that the affected parties reach agreement regarding the relationship. Logic reviews should start at the lowest levels of complexity, then up through the schedule. For example, start with each CAM to review control account logic, then meet with groups of CAMs or IPTs to review interdependencies, then review logic with the systems engineer / chief engineer / production manager; and, lastly with the program manager.

Networking meeting (or Linking Party / Wall walk)

One method of reviewing the network logic is for everyone involved in the planning to attend a network meeting, or "Linking Party." Task owners are the vital participants in this meeting ensuring network accuracy and completeness. The meeting format may vary depending on the size of the schedule. Larger programs may print sections of the IMS logic network diagram and attach them to a conference room wall for review. This allows task owners to review and collectively discuss the information and make comments and corrections during the discussion.

Smaller programs may project the schedule as a presentation and make the suggested changes real time until reaching consensus.

Critical Path/Driving Path check

Validate the Critical Path and Near Critical Path to the end of the program, then the Driving and Near Driving Paths to key program milestones with the program team (Refer to the Critical and Driving Path methods and Analysis chapter for more information).

Calculations

Refer to the Schedule Calculation Algorithm chapter for details on horizontal traceability factors into total float, free float, early/late dates, etc.

Optional Techniques

The section above describes several options for establishing horizontal traceability. The approaches will vary depending on the size and complexity of the program and whether there are many CAMs, IPTs, or suppliers. Additionally, the scheduling tools or approaches may vary depending on whether the program team uses only one scheduling tool, stand-alone schedules, or multiple files and whether the data is always integrated or is updated periodically via merging or linking multiple schedule files.

Things to Promote

Ensure the use of early date constraints is necessary and avoid using them in place of accurate schedule logic between tasks and milestones. Document the use of early date constraints in the IMS. Appropriate uses of early date constraints include but are not limited to the following: near term tasks when known starts are more accurate than the predecessor logic, inputs driven from sources external to the IMS, and to reflect the impact of people, equipment or facility resource constraints.

Ensure that external schedule dependencies (i.e. subcontractors) are taken into consideration when assessing and validating the horizontal integration of an IMS. See the Subproject/External Schedule integration section for more information.

Employ attention to network logic when performing network status updates and baseline maintenance. Modify logical relationships to accurately reflect the current program path forward and resolve out-of-sequence status conditions.

As discussed in the Forecasting chapter; validate and update the program's network logic during each update cycle to ensure it matches the current program workflow and execution strategy.

Things to Avoid

Linking for convenience

If there is no real logical relationship between two tasks, then avoid selecting a predecessor task that has a completion date immediately before a task is supposed to begin. The convenient predecessor task has no relationship to the task in need of a predecessor. This inaccurate linking will affect the accuracy of assessing the impacts of schedule changes and likely require revisions to the network logic.

Redundant links

Identify all required relationships but avoid redundant ties (Figure 8.1-1). These are unnecessary and add confusion to understanding and analyzing the logic network. As you identify redundant links, remove them.

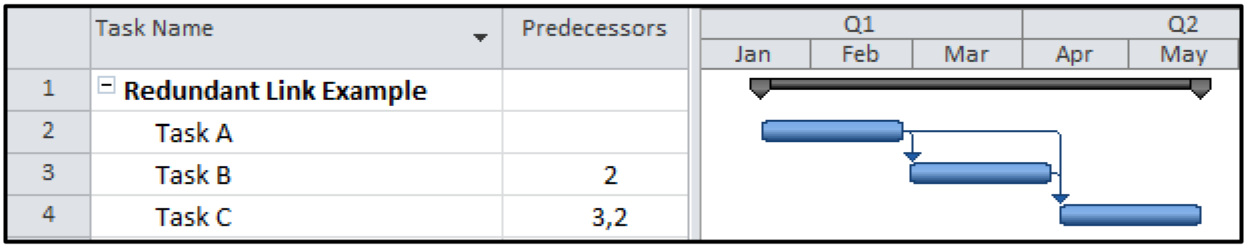


Figure 8.1-1 Example or redundant relationships, which may need to be removed

In this example (Figure 8.1-1), Task C has both Task A and Task B as predecessors. The link from Task A to Task C is redundant and can/should be removed.

Logic ties to summary tasks

Avoid assigning logic relationships at the Summary Task level as this may have unintended consequences on its subtasks and their logic relationships to tasks outside the Summary. It is also difficult to analyze the schedule when sorting detail tasks if the logic exists at the Summary Task level. Assign predecessors and successors at the detail task level.

Open Ended Tasks

Activities or tasks created without predecessors or successors have what is called “open ended” or “dangling” logic. Fundamentally, although a start-to-start successor or a finish-to-finish predecessor is proper and sometimes useful, it is not sufficient to avoid dangling logic. With dangling logic, risk in activities will not automatically cascade down to their successors when updating schedule status or forecasts. Sound horizontal traceability is crucial during Schedule Risk Assessments when activity durations are changed iteratively. Without this logic, the simulation will not be able to identify the correct dates and critical path. When resolving open-ended tasks, ensure that the resulting logic accurately reflects the task workflow and inter-relationships.

Logic ties to Level of Effort

Avoid assigning logic relationships between discrete and level of effort tasking as this can result in a miscalculation of the program’s workflow and critical path. Refer to the LOE topic within the guide for the appropriate methodologies of modeling LOE in the IMS.

Related Topics

Critical and Driving Path Analysis
Vertical Integration and Traceability
Schedule Architecture
Relationships / Logic
Subproject/External Schedule Integration
Task Constraints

8.2 Vertical Integration and Traceability

Manager's View

Vertical Integration and Traceability is defined as having demonstrable compatibility between the baseline, actual, and forecast dates, status, and work scope requirements at all levels of schedule detail. This type of schedule integration is imperative to its credibility and ensures completeness of the technical, cost and schedule baseline. Vertical Integration and Traceability demonstrates that the schedule has predecessor logic supporting program milestones where lower level detail tasks determine impacts to these milestones. Program milestones reflect the sequence of program execution and provide focus, identifying schedule drivers and impacts to those Milestones by following the Critical Path/Driving Path, providing an understanding of key events and whether desired program end-states will be met. Vertical Integration and Traceability also demonstrates the use of key technical information in planning the schedule, indicating alignment with documents such as the Statement of Work (SOW), Work Breakdown Structure (WBS), and the Integrated Master Plan (IMP). The detail tasks have codes relating the work efforts to these technical source documents.

Description

Vertical Integration and Traceability occurs when data element relationships between the detailed IMS activities and various requirements and structural elements are captured to ensure the technical, schedule and cost baselines demonstrate traceability to, and consistency with one another. Vertical Integration and Traceability is achieved when work products are fully integrated during the initial schedule development. Vertical Integration and Traceability should be maintained during program execution (throughout the life of the program) to ensure the integrity of the work product integration, necessary to provide a comprehensive and complete Performance Management Baseline.

Program schedules should exhibit Vertical Integration and Traceability of dates between all levels of schedules: Summary Master Schedule, Intermediate Level Schedule, and Detailed Schedule. In addition, the detailed schedule should be vertically traceable to the various requirements and structural elements detailed here:

IMP

The IMP is an event-based plan that provides a breakout of the work required to accomplish each Event and to successfully complete the program. The IMS is aligned with the IMP. Tasks and milestones in the IMS are directly traceable to IMP events and criteria when an IMP is used to develop the IMS structure.

The IMP decomposes the program into:

- Program Events - summarizes the program at "tier one" level milestones
- Significant Accomplishments – summarizes the statement of work at "tier two".
- Accomplishment Criteria - defines the exit criteria for each accomplishment.

Reference the IMP overview in the Schedule Architecture section for additional information.

SOW/SOO

The Statement of Work (SOW) and Statement of Objectives (SOO) are formal documents that capture and define the work activities, deliverables and timeline a vendor will execute against in performance of specified work for a customer. The SOW/SOO provides insight to data that should be included in the IMP and the IMS. Detailed requirements for pricing are usually included in the SOW/SOO, along with standard regulatory and governance terms and conditions. It identifies tasks to be completed and states required performance outcomes. It provides the basis for planning the product's functionality, characteristics, and attributes. The contractor or subcontractor uses the SOW to expand the WBS to lower levels of detail and to develop the IMS. The SOW paragraph and WBS elements are directly traceable to IMS tasks/activities and contractual delivery dates.

TRD

When a Technical Requirements Document (TRD) is part of the Program Technical Baseline, one should also maintain traceability between the TRD sub-sections and the IMS tasking. Ensuring all TRD requirements are traceable to IMS tasking reinforces the concept that the entire scope of the program has been addressed in the IMS. It also identifies when those TRD requirements are expected to be closed, providing Risk Register status visibility to the current state of identified Risks and Opportunities. Ensure that an appropriate TRD sub-level is identified as the point of maintaining traceability to avoid driving the IMS to an unmanageable level of detail.

CLIN

As applicable, effort within a Contract Line Item (CLIN) in the IMS should be vertically traceable to the relevant CLIN in the contract. This includes cost, technical, and schedule requirements specific to the CLIN.

CDRL

The Contract Data Requirements List (CDRL) identifies the data items to be developed and delivered on a specific procurement or program. The CDRL provides contractor guidance for preparation and submitting of reports, including reporting frequency, distribution, formatting, and tailoring instructions. All discrete and non-recurring CDRLs should be traceable to detailed IMS tasks/activities.

Note: On subcontract efforts, this is referred to as a Subcontract Data Requirements List (SDRL) which carries the same Vertical Integration and Traceability requirements.

OBS

The Organization Breakdown Structure (OBS) is a functionally oriented division of the contractor's organization established to perform work on specific contract. Each control account (see control account section below) is associated with a specific single organizational component in the OBS. Each IMS activity/task is assigned and traceable to one Control Account within the OBS.

WBS

The Work Breakdown Structure (WBS) is a product oriented hierarchical decomposition of the work to be executed on the program. The WBS is derived from the SOW and provides a common framework for the natural development of the overall planning and control of a contract. It is the basis for dividing work into definable increments from which the IMS can be established. Each IMS task/activity is assigned and traceable to one WBS element.

Control Account

The Control Account (CA) is a management control point where scope, budget, actual cost, and schedule are integrated to facilitate effective program management via cost/schedule planning, execution, and performance analysis. Control accounts are the lowest point of the WBS where assignment of work responsibility is given to a Control Account Manager (CAM). Each discrete IMS task/activity with resources is assigned and traceable to only one Control Account.

Work Package

A Work Package (WP) represents a segment of a Control Account's work scope. The WP is broken out into an IMS task or set of tasks to create the schedule activities and schedule milestones required to complete the work package deliverable. With the exception of SVT tasking, each IMS task/activity is traceable to one WP.

Note: Planning Packages (PP) represent future efforts that are not yet detail planned to one or more WPs. PPs carry the same IMS traceability requirements as WPs.

Lower Level Schedules/Steps/Inchstones/Quantifiable Backup Data (QBD)

Lower level schedules, inch-stones, or steps are the lower level items required to achieve completion of IMS tasks/activities. They can reside inside or outside of the IMS model and have a period of performance that aligns with the Work Package they support. If used to quantify performance during schedule status update, then inch-stones or steps are referred to as Quantifiable Backup Data (QBD). These QBD documents may be known as Manufacturing Build Process Sheets, Objective Indicator Milestone Plans, Apportioned Effort Plans, CAM Objective EV Plans, etc. Quantifiable Backup Data (QBD's) do not have to contain a period of performance when used solely to calculate task progress. QBD elements can be accomplished in any order.

Schedule Hierarchy

In order to facilitate the needs of many different stakeholders, programs maintain multiple levels of schedule hierarchy. Program teams define the information necessary at each level to aid in the use of the schedules as an effective and efficient communication vehicle. The dates between each level of the schedules should be vertically traceable but do not necessarily need to reside in the same "file" or tool.

Schedule Hierarchy is as follows:

- Level 1 – Summary Master Schedules
- Level 2 – Intermediate Schedules
- Level 3 – Detailed Schedules

Example

The following example (Figure 8.2-1) demonstrates on a handful of elements (not an all-inclusive list) how IMS coding can be used to maintain and validate Vertical Integration and Traceability.

SOW	OBS	CLIN	IMP ID	WBS#	Control Account	Task Name
			5.0			**Internal Integration & Pre-Qual Test Completed**
			5.1	**1.1.6.5**		**GNC Software Builds Completed**
			5.1.2	**1.1.6.5a**		**GNC Software Build 1 Completed**
2.7.2	GNC	CLIN 1	5.1.2	1.1.6.5a	1.1.6.5a.1	Review GNC SW Build 1 Requirements Changes
2.7.2	GNC	CLIN 1	5.1.2	1.1.6.5a	1.1.6.5a.1	Review GNC SW Build 1 Design Changes
2.7.2	GNC	CLIN 1	5.1.2	1.1.6.5a	1.1.6.5a.1	Code GNC SW Build 1
2.7.2	GNC	CLIN 1	5.1.2	1.1.6.5a	1.1.6.5a.2	Conduct GNC SW Build 1 Unit Test
			5.1.3	**1.1.6.5b**		**GNC Software Build 2 Completed**
2.7.2	GNC	CLIN 1	5.1.3	1.1.6.5b	1.1.6.5b.1	Review GNC SW Build 2 Requirements Changes
2.7.2	GNC	CLIN 1	5.1.3	1.1.6.5b	1.1.6.5b.1	Review GNC SW Build 2 Design Changes
2.7.2	GNC	CLIN 1	5.1.3	1.1.6.5b	1.1.6.5b.1	Code GNC SW Build 2
2.7.2	GNC	CLIN 1	5.1.3	1.1.6.5b	1.1.6.5b.2	Conduct GNC SW Build 2 Unit Test
			5.1.4	**1.1.6.5c**		**GNC Software Build 3 Completed**
2.7.2	GNC	CLIN 1	5.1.4	1.1.6.5c	1.1.6.5c.1	Review GNC SW Build 3 Requirements Changes
2.7.2	GNC	CLIN 1	5.1.4	1.1.6.5c	1.1.6.5c.1	Review GNC SW Build 3 Design Changes
2.7.2	GNC	CLIN 1	5.1.4	1.1.6.5c	1.1.6.5c.1	Code GNC SW Build 3
2.7.2	GNC	CLIN 1	5.1.4	1.1.6.5c	1.1.6.5c.1	Conduct GNC SW Build 3 Unit Test

Figure 8.2-1 Example of IMS coding to support Vertical Integration and Traceability

Things to Promote

Detail Level Schedules - Ensure that the level of detail in the IMS is sufficient to capture the key workflow Hand-offs in primarily Finish-To-Start relationships types. This ensures the most accurate IMS model possible as the finish of detailed tasks drive the start of their succeeding work.

It is recommended that Quantifiable Backup Data (QBD) be managed under an established control process in the IMS Supplemental Guidance document.

Reconciliation of Vertical Integration and Traceability should be conducted throughout the life cycle of the program and not just during program start-up.

When constructing your IMS, ensure to understand the order of precedence in the proposal and/or contract of all relative elements such as the SOW/SOO, CDRL documents, TRD and other program supplied documents.

Ensure buy-in for all levels of the project schedule by having all affected stakeholders participate in the schedule review process.

Things to Avoid

Producing an inaccurate picture of the program schedule that is not vertically traceable to the IMS and the elements listed in this section.

Related Topics

Horizontal Traceability
Schedule Modeling Techniques
Rolling Wave Planning
Baseline Change Management

8.3 Task Coding

Manager's View

An effective and controlled task coding process is essential to ensuring the horizontal and vertical integration and traceability of the IMS model, as well as to continually manage and update the schedule. Additionally, sorting, filtering and grouping program data is an integral part of data analysis and usability for program personnel at all levels. Capturing essential data leads to smart decision-making and helps Program Managers get a better handle on the current status of the program. Sorting data helps to quickly visualize and understand the data, organize and find significant data, and ultimately facilitates more effective decision making. In addition, using a standardized naming convention is fundamental to schedule architecture in order to optimize the time the program team spends building, maintaining, analyzing, and reporting on the IMS.

Description

Task coding captures and maintains reference information related to a specific task in predefined IMS data fields. It provides data for sorting, filtering and grouping tasks which enhances the ability to analyze the schedule and facilitates Vertical Integration and Traceability.

Most Common Traceability Elements

The following table contains a list of common data fields used to provide traceability and enhance the capability to sort, group, and filter schedule information.

Activity Owner (Control Account Manager)	Multi-Project Unique Identifier
Planning or Work Package Identifier	Government Furnished Equipment / Information
Integrated Product Team (IPT)	Integrated Master Plan Identifier
Organizational Breakdown Structure (OBS)	Earned Value Technique
Work Breakdown Structure (WBS)	Earned Value Percent Complete
Statement of Work (SOW) Paragraph	Physical (Scope Based) Percent Complete
Schedule Visibility Task (SVT) Identifier	Schedule Margin Code
Control Account Identifier	Contract Line Item Number (CLIN)

Figure 8.3-1 Common Traceability Elements

Custom Fields for Organizing Data

Different stakeholders may request specific additional data fields to be included in the IMS model. The reason for this additional data is to support the organization of the IMS data using these fields as filtering and sorting parameters. Data is broken down into groups in order to make it easier to read, understand and analyze. It also enables delivery of only the data needed by the user.

Examples

In this example (Figure 8.3-2), we see three coding fields populated with data (CAM, CWBS, IPT).

Task Name	Duration	Start	Finish	CAM	CWBS	IPT
GNC Software Build 1	**70 days**	**1/20**	**4/26**			
Determine GNC SW Build 1 Requirements	10 days	1/20	2/2	Bob Jones	1.1.6.5a	GNC
Conduct GNC SW Build 1 Design	20 days	2/3	3/1	Bob Jones	1.1.6.5a	GNC
Code GNC SW Build 1	30 days	3/2	4/12	Bob Jones	1.1.6.5a	GNC
Conduct GNC SW Build 1 Unit Test	10 days	4/13	4/26	Mike Roy	1.1.6.5a	GNC
GNC Software Build 2	**70 days**	**4/13**	**7/19**			
Determine GNC SW Build 2 Requirements	10 days	4/13	4/26	Bob Jones	1.1.6.5b	GNC
Conduct GNC SW Build 2 Design	20 days	4/27	5/24	Bob Jones	1.1.6.5b	GNC
Code GNC SW Build 2	30 days	5/25	7/5	Bob Jones	1.1.6.5b	GNC
Conduct GNC SW Build 2 Unit Test	10 days	7/6	7/19	Mike Roy	1.1.6.5b	GNC
GNC Software Build 3	**70 days**	**7/6**	**10/11**			
Determine GNC SW Build 3 Requirements	10 days	7/6	7/19	Bob Jones	1.1.6.5c	GNC
Conduct GNC SW Build 3 Design	20 days	7/20	8/16	Bob Jones	1.1.6.5c	GNC
Code GNC SW Build 3	30 days	8/17	9/27	Bob Jones	1.1.6.5c	GNC
Conduct GNC SW Build 3 Unit Test	10 days	9/28	10/11	Mike Roy	1.1.6.5c	GNC

Figure 8.3-2 Example of coding fields and their use on IMS tasks

In this example (Figure 8.3-3), we see the IMS filtered to only show tasks with CWBS = 1.1.6.5b

Task Name	Duration	Start	Finish	CAM	CWBS	IPT
Determine GNC SW Build 2 Requirements	10 days	4/13	4/26	Bob Jones	1.1.6.5b	GNC
Conduct GNC SW Build 2 Design	20 days	4/27	5/24	Bob Jones	1.1.6.5b	GNC
Code GNC SW Build 2	30 days	5/25	7/5	Bob Jones	1.1.6.5b	GNC
Conduct GNC SW Build 2 Unit Test	10 days	7/6	7/19	Mike Roy	1.1.6.5b	GNC

Figure 8.3-3 Filtered IMS to display only CWBS=1.1.6.5b

In this example (Figure 8.3-4), we see the IMS grouped by CAM.

Task Name	Duration	Start	Finish	CAM	CWBS	IPT
CAM: Bob Jones	**30d**	**1/20**	**9/27**			
Determine GNC SW Build 1 Requirements	10 days	1/20	2/2	Bob Jones	1.1.6.5a	GNC
Conduct GNC SW Build 1 Design	20 days	2/3	3/1	Bob Jones	1.1.6.5a	GNC
Code GNC SW Build 1	30 days	3/2	4/12	Bob Jones	1.1.6.5a	GNC
Determine GNC SW Build 2 Requirements	10 days	4/13	4/26	Bob Jones	1.1.6.5b	GNC
Conduct GNC SW Build 2 Design	20 days	4/27	5/24	Bob Jones	1.1.6.5b	GNC
Code GNC SW Build 2	30 days	5/25	7/5	Bob Jones	1.1.6.5b	GNC
Determine GNC SW Build 3 Requirements	10 days	7/6	7/19	Bob Jones	1.1.6.5c	GNC
Conduct GNC SW Build 3 Design	20 days	7/20	8/16	Bob Jones	1.1.6.5c	GNC
Code GNC SW Build 3	30 days	8/17	9/27	Bob Jones	1.1.6.5c	GNC
CAM: Mike Roy	**10d**	**4/13**	**10/11**			
Conduct GNC SW Build 1 Unit Test	10 days	4/13	4/26	Mike Roy	1.1.6.5a	GNC
Conduct GNC SW Build 2 Unit Test	10 days	7/6	7/19	Mike Roy	1.1.6.5b	GNC
Conduct GNC SW Build 3 Unit Test	10 days	9/28	10/11	Mike Roy	1.1.6.5c	GNC

Figure 8.3-4 Example of an IMS Grouping

Things to Promote

Capture task coding in specific fields in a data dictionary. See the IMS Supplemental Guidance chapter.

All changes affecting the predefined data fields need to be captured in the Integrated Master Schedule and maintain consistency with all authorizing documents.

Minimize data entry errors by documenting source documents for code fields (e.g., the Responsibility Assignment Matrix (RAM) or WBS Dictionary might contain the CA, CAM, WBS, SOW, and even IMP fields in one place) and by building in data validation into the schedule maintenance and baseline change processes.

Early in the IMS architecting phase, the program team should identify required schedule management reports prior to creating the IMS. This will help to facilitate the creation of task coding necessary to support schedule management report generation for the program.

Things to Avoid

Avoid disconnects in vertical and horizontal traceability between the IMS and the authorizing documents and program structures. See the Vertical Integration and Traceability and Horizontal Traceability chapters.

Related Topics

- Vertical Traceability and Traceability
- Horizontal Traceability
- Submittal of IMS Data
- Task Naming Convention

9 Schedule Maintenance

This section contains the following chapters.

9.1 Statusing

This section contains the following chapters.

9.1.1 Statusing to Time Now

Manager's View

On a recurring basis (i.e. weekly, biweekly, or monthly) the IMS is updated to capture performance and reflect adjustments to the forecast. The frequency of status is important to consider as it clarifies the program position and priorities in addition to identifying issues requiring mitigation that would go unnoticed had the schedule not had its status updated. On most programs, the recommended IMS status frequency is weekly or biweekly.

Time Now, also known as the status date or data date, is simply the date that the IMS considers as "today". This date is commonly aligned with accounting system End-Of-Month closeout dates. Everything to the left of Time Now actually occurred and is in the past; everything to the right of Time Now has yet to occur and is in the future. It is essential that the IMS status be consistent with Time Now to ensure accurate forecast dates.

Description

During the status process, task owners assess the progress of all tasks that occurred within the status window. Additionally, they validate and correct the logical relationships, remaining durations, and constraints of future tasks. Reference section 9.1.2, entitled "Forecasting", which covers the validation and correction of future tasks.

Task owners answer the following six questions during the status process for each of their applicable tasks:

1. If the task started, when did it start?
    a. Capture this date in the IMS as the Actual Start Date.
2. If the task did not start, when will it start?
    a. The resulting date represents the new Forecast/Early Start Date. Capture this date in the IMS by adding a missing predecessor or the forecasted start date (as a soft constraint).
3. If the task finished, when did it finish?
    a. Capture this date in the IMS as the Actual Finish Date.
4. If the task did not finish, how much duration is required to finish it?
    a. This date represents the new Forecast/Early Finish Date. Capture this date in the IMS by adjusting the task's Remaining Duration.

       Or
    b. Capture this date by entering the Forecast Finish Date and letting the tool calculate the remaining duration. (Note: not all tools allow this method of statusing).
5. What is the Percent Complete of the task?
    a. Capture this element in the IMS as the Percent Complete.

    Note on Percent Complete. There are a number of different Percent Complete fields available for use within all scheduling systems. They include Percent Complete values that indicate percentages of duration, work (hours), earned value, and scope. It is important that the program understand the differences between these values, how they are calculated, and update the correct Percent Complete values during the status process.

6. For resource loaded tasks, how many hours are expected to be expended to complete the scope of the task?
    a. This will represent the Estimate to Complete (ETC) for the task. Capture this value by updating the remaining resources field (actual field name will vary depending on the scheduling tool).

Note on ETC. Some tasks like "travel" may necessitate an assessment in dollars instead of hours

Examples

In this example (Figure 9.1.1-1), Task 2 has not started and is sitting to the left of Time Now (Forecast in Past – ERROR). This results in an inaccurately forecasted XYZ CDR date of March 4th. The status update is corrected to align with Time Now, resulting in a now accurate forecast relative to the XYZ CDR date of March 25th (Forecast in Past – CORRECTION).

	Task Name	% Complete	Duration	Start	Finish	Actual Start	Actual Finish	Remaining Duration
1	**Forecast in Past - ERROR**	**0%**	**40 days**	**1/11**	**3/4**	**NA**	**NA**	**40 days**
2	Conduct XYZ System Detailed Design	0%	30 days	1/11	2/19	NA	NA	30 days
3	Prepare for XYZ CDR	0%	10 days	2/22	3/4	NA	NA	10 days
4	XYZ CDR	0%	0 days	3/4	3/4	NA	NA	0 days
5								
6	**Forecast in Past - CORRECTION**	**0%**	**40 days**	**2/1**	**3/25**	**NA**	**NA**	**40 days**
7	Conduct XYZ System Detailed Design	0%	30 days	2/1	3/11	NA	NA	30 days
8	Prepare for XYZ CDR	0%	10 days	3/14	3/25	NA	NA	10 days
9	XYZ CDR	0%	0 days	3/25	3/25	NA	NA	0 days

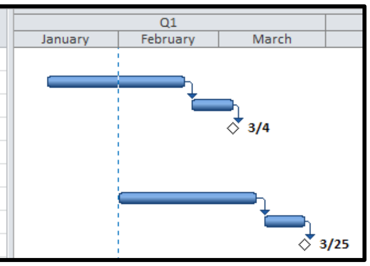


Figure 9.1.1-1 Impact of improper forecast update in the IMS

In this example (Figure 9.1.1-2), Task 2 has an Actual Finish date sitting to the right of Time Now (Actuals in the Future – ERROR). This results in an inaccurately forecasted XYZ CDR date of March 4th. This status information, corrected to align with Time Now, results in a now accurately forecasted XYZ CDR occurring on February 12th (Actuals in the Future – CORRECTION).

	Task Name	% Complete	Duration	Start	Finish	Actual Start	Actual Finish	Remaining Duration
1	**Actuals in Future - ERROR**	**75%**	**40 days**	**1/11**	**3/4**	**1/11**	**NA**	**10 days**
2	Conduct XYZ System Detailed Design	100%	30 days	1/11	2/19	1/11	2/19	0 days
3	Prepare for XYZ CDR	0%	10 days	2/22	3/4	NA	NA	10 days
4	XYZ CDR	0%	0 days	3/4	3/4	NA	NA	0 days
5								
6	**Actuals in Future - CORRECTION**	**60%**	**25 days**	**1/11**	**2/12**	**1/11**	**NA**	**10 days**
7	Conduct XYZ System Detailed Design	100%	15 days	1/11	1/31	1/11	1/31	0 days
8	Prepare for XYZ CDR	0%	10 days	2/1	2/12	NA	NA	10 days
9	XYZ CDR	0%	0 days	2/12	2/12	NA	NA	0 days

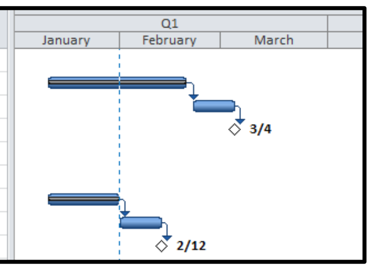


Figure 9.1.1-2 Impact of inaccurate Actual Start to Time Now and the Estimate to Complete (ETC)

In this example (Figure 9.1.1-3), Task 2 has Remaining Duration sitting to the left of Time Now (In-process Activity – ERROR). This results in an inaccurately forecasted XYZ CDR date of March 4th. The status, corrected relative to Time Now, resulting in a now accurately forecasted XYZ CDR date of March 18th (In-process Activity – CORRECTION).

	Task Name	% Complete	Duration	Start	Finish	Actual Start	Actual Finish	Remaining Duration
1	**In-process Activity - ERROR**	**15%**	**40 days**	**1/11**	**3/4**	**1/11**	**NA**	**34 days**
2	Conduct XYZ System Detailed Design	20%	30 days	1/11	2/19	1/11	NA	24 days
3	Prepare for XYZ CDR	0%	10 days	2/22	3/4	NA	NA	10 days
4	XYZ CDR	0%	0 days	3/4	3/4	NA	NA	0 days
5								
6	**In-process Activity - CORRECTION**	**31%**	**49 days**	**1/11**	**3/18**	**1/11**	**NA**	**34 days**
7	Conduct XYZ System Detailed Design	39%	39 days	1/11	3/4	1/11	NA	24 days
8	Prepare for XYZ CDR	0%	10 days	3/4	3/18	NA	NA	10 days
9	XYZ CDR	0%	0 days	3/18	3/18	NA	NA	0 days

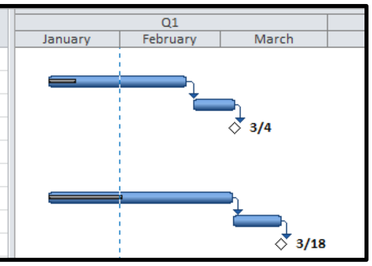


Figure 9.1.1-3 Impact of Remaining Duration to the Left of Time Now

In this example (Figure 9.1.1-4), the "Prepare for XYX CDR" task has already started even though it has a Finish-to-Start predecessor that has not finished (Out-of-Sequence Logic – ERROR). This results in an inaccurately forecasted XYZ CDR date of February 8th. The logic, corrected to reflect a Finish-to-Finish relationship, now results in an accurately forecasted XYZ CDR date of February 26th (Out-of-Sequence Logic – CORRECTION).

	Task Name	Duration	Start	Finish	Predecessors
1	**Out-of-Sequence Logic - ERROR**	**30 days**	**1/11**	**2/19**	
2	Conduct XYZ System Detailed Design	30 days	1/11	2/19	
3	Prepare for XYZ CDR	10 days	1/26	2/8	2
4	XYZ CDR	0 days	2/8	2/8	3
5					
6	**Out-of-Sequence Logic - CORRECTION**	**35 days**	**1/11**	**2/26**	
7	Conduct XYZ System Detailed Design	30 days	1/11	2/19	
8	Prepare for XYZ CDR	24 days	1/26	2/26	7FF+5 days
9	XYZ CDR	0 days	2/26	2/26	8

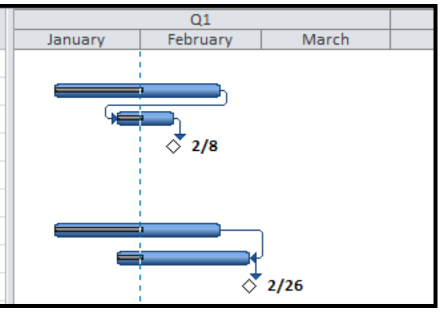


Figure 9.1.1-4 Impact of Out-of-Sequence Logic

Note: Some scheduling software tools automatically enforce Time Now and therefore would not exhibit the errors depicted in these examples. Ensure that the schedule management team understands the business rules of their scheduling tool and that their status process works in concert with the tool's capabilities.

Calculations

For in-process tasks:

- Time Now – Actual Start = Actual Duration
- Time Now + Remaining Duration = Forecasted Early Finish

Optional Techniques

In some circumstances, task owners may necessitate the splitting of in-process tasks.

Things to Promote

Ensure that at least one of the schedule status cycles coincides with the accounting month end to ensure consistency of Earned Value calculation and reporting.

If your scheduling tool does not enforce Time Now, then follow a process that ensures the schedule status is consistent with Time Now.

Programs should status the IMS as frequently as possible. However, assess and report Earned Value performance in accordance with contractual and internal requirements. Status frequency should be consistent with programmatic needs.

Schedule management teams should ensure they thoroughly understand and consistently apply the calculation options within the scheduling tool.

Use the level of detail in the IMS as a variable in determining the appropriate status frequency.

During the status process, to properly reschedule a task that did not start inside the status window, first ensure the task is not missing predecessors before applying a constraint.

Validation of status should include the verification of actual costs in the current period to support opening or closing of a task. Status change in the absence of actual costs is often indicative of a need for a labor transfer due to inaccuracies in labor charging.

Ensure that the methodology for planning and progressing material in the IMS is consistent with the company's process for handling material accrual and/or vouchering.

Ensure the program culture supports and enforces accurate and executable status updates. If task owners inaccurately capture task performance or model their tasking in a way that is likely not executable than the analysis of the IMS may lead to incorrect program management decisions.

Things to Avoid

Avoid status updates to the out-of-sequence tasks without correcting the out-of-sequence task relationships to reflect the correct and current task workflow.

Avoid common status update errors (for example, tasks 100% complete without actual dates or tasks updated inconsistent with Time Now).

Related Topics

Forecasting
Critical and Driving Path Analysis
Schedule Calculation Algorithm
Duration-Based v. Scope-Based Percent Complete

9.1.2 Forecasting

Manager's View

During each status period, the program addresses all tasks forecasted to occur within the status window. It is equally important, however, that the program team also validates and updates the not started and in-process tasks in the IMS. Forecasting is the process of validating the durations and logical relationships of not started and in-process tasks. It may also include a refresh of estimated resource needs. Forecasting ensures the IMS contains the most up to date information, is executable, and accurately represents the program position and priorities.

Description

The following table (Figure 9.1.2-1) contains a list of schedule quality control steps used by program planners, task owners, and program leadership during the "forecasting" process to validate that the IMS is accurate and executable.

Schedule QC Item	Description
Schedule Health Assessment	Perform iterative health assessments throughout the status and forecasting processes to identify and resolve potential errors to the IMS structure (refer to the Schedule Health Assessment chapter in this guide).
Duration Check	Validate that the remaining durations are accurate and executable by using past performance on like tasks as a basis for comparison (refer to the Task Durations chapter in this guide). Compare the duration-based percent complete with the scope- based percent complete on in-process tasks (refer to section 10.4.7 "Duration-Based v. Scope Based Percent Complete" chapter in this guide).
Logic Check	Validate that the logical relationships on future tasks are accurate (refer to the Relationships/Logic chapter in this guide). Ensure that the "givers" and "receivers" agree to the schedule and product fidelity of expected Hand-offs. Analyze lags and leads to ensure they are accurate (refer to section 5.4 "Lead / Lag Time" chapter in this guide). Remove redundant and unnecessary logical relationships. Correct out of sequence logic errors. Resolve any circular logic errors (or loops). Note: some schedule software tools resolve circular logic errors at time of input. Other software tools display calculation errors and others may not display any indication of an error until you attempt to close the file, at which time it may advise you of a loop error. In this case, the only indication one will see is that the IMS does not re-calculate the IMS after each task change.
Resource De-confliction	Analyze key resources (i.e. people, places, and things) to identify and mitigate requirement overlaps.
Resource Estimates	To ensure accurate Estimate to Complete calculations it is important to ensure that the IMS contains the most current resource estimates available.

Schedule QC Item	Description
Bow Wave Analysis	Identify bow waves created by task owners "kicking the can" and pushing tasks into the next status period as this often results in an unachievable forecasted schedule (refer to section 10.4.8 "Schedule Rate Chart" chapter in this guide).
Critical / Driving Path Analysis	Perform critical and driving path analysis to the program end and interim milestones (refer to section 10.1 "Critical/Driving Path Analysis" chapter in this guide). Validate that the resulting paths are accurate. Analyze and mitigate impacts to the required contractual/target dates by utilizing schedule accelerations methods (refer to section 9.1.3 "Schedule Acceleration Techniques" chapter in this guide).
Schedule Margin	Analyze the Program Manager's assessment of schedule margin to interim and program end milestones and mitigate any unacceptable impact by using schedule acceleration techniques (refer to section 9.1.3 "Schedule Acceleration Techniques" chapter in this guide).
Management Check	Validate that all appropriate management stakeholders concur with the forecasted schedule prior to completing the forecasting process (refer to section 11.5 "Program Schedule Reviews" chapter in this guide).
IMS to Lower level Schedule Status Check	Validate that the IMS Status is in alignment with lower level schedules, as applicable (including inchstones, steps and Quantifiable Backup Date (QBD's))
Historical versus Forecast Rate of Accomplishment Check	Compare the historical versus the forecasted rates of accomplishment from multiple sources (including schedule rate charts (S-Curves), BEI, SPI, Shop Floor outputs, etc.) to identify delta's between historical and forecasted completions. The forecasted IMS may be inaccurate if the forecast plan suggests a rate of accomplishment that is significantly higher than the program has achieved historically.

Figure 9.1.2-1 Quality Control Checks to Validate Status Updates

Examples

Below are two representative examples that demonstrate the benefits of a robust "forecasting" process.

In this example (Figure 9.1.2-2), the task owner knows that a resource has been lost and that Task 3, "Prepare for XYZ CDR", is going to take longer than the IMS currently represents. As this task was not in the status window the duration was not updated which results in an inaccurately forecasted XYZ CDR date of March 18th.

The "Prepare for XYZ CDR" task, corrected to include this duration increase, now drives an accurately forecasted XYZ CDR date of April 1st.

	Task Name	% Complete	Duration	Start	Finish	Actual Start	Actual Finish	Remaining Duration
1	Forecast Duration - ERROR	30%	50 days	1/11	3/18	1/11	NA	35 days
2	Conduct XYZ System Detailed Design	38%	40 days	1/11	3/4	1/11	NA	25 days
3	Prepare for XYZ CDR	0%	10 days	3/7	3/18	NA	NA	10 days
4	XYZ CDR	0%	0 days	3/18	3/18	NA	NA	0 days
5								
6	Forecast Duration - CORRECTION	25%	60 days	1/11	4/1	1/11	NA	45 days
7	Conduct XYZ System Detailed Design	38%	40 days	1/11	3/4	1/11	NA	25 days
8	Prepare for XYZ CDR	0%	20 days	3/7	4/1	NA	NA	20 days
9	XYZ CDR	0%	0 days	4/1	4/1	NA	NA	0 days

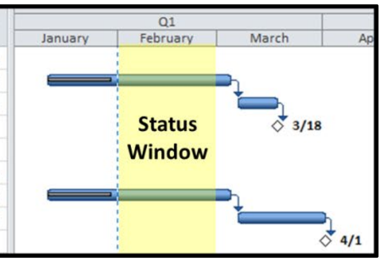


Figure 9.1.2-2 Example of an inaccurate forecast on a task outside of the current Status Window

In this example (Figure 9.1.2-3), the task owner knows that as long as subcontractor CDRs are complete, Task 3 “Prepare for XYZ CDR” can occur in parallel with Task 2 “Conduct XYZ System Detailed Design”. As this task was not in the status window, the logic was not updated, resulting in an inaccurately forecasted XYZ CDR date of March 18th.

The “Prepare for XYZ CDR” task, corrected to include this logic change, now drives an accurately forecasted XYZ CDR date of March 4th.

	Task Name	% Complete	Duration	Start	Finish	Actual Start	Actual Finish	Remaining Duration
1	Forecast Duration - ERROR	30%	50 days	1/11	3/18	1/11	NA	35 days
2	Conduct XYZ System Detailed Design	38%	40 days	1/11	3/4	1/11	NA	25 days
3	Prepare for XYZ CDR	0%	10 days	3/7	3/18	NA	NA	10 days
4	XYZ CDR	0%	0 days	3/18	3/18	NA	NA	0 days
5								
6	Forecast Duration - CORRECTION	30%	40 days	1/11	3/4	1/11	NA	28 days
7	Conduct XYZ System Detailed Design	38%	40 days	1/11	3/4	1/11	NA	25 days
8	Subcontractor CDRs Complete	0%	0 days	2/22	2/22	NA	NA	0 days
9	Prepare for XYZ CDR	0%	10 days	2/22	3/4	NA	NA	10 days
10	XYZ CDR	0%	0 days	3/4	3/4	NA	NA	0 days

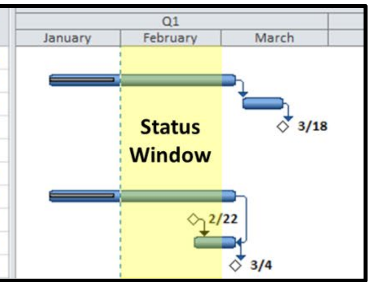


Figure 9.1.2-3 Example of a status that is missing a Logic Update outside of the Status Window

Things to Promote

Ensure the schedule management team understands and consistently applies the configurable schedule calculation options.

Things to Avoid

Avoid artificially breaking logic or reducing durations to “maintain schedule”.

Related Topics

- Statusing to Time Now
- Critical and Driving Path Analysis
- Schedule Calculation Algorithm
- Estimate at Completion
- Duration-Based v. Scope-Based Percent Complete

9.1.3 Schedule Acceleration Techniques

Manager's View

The techniques described in this section are methodologies that programs can employ to pull schedule forecasts to the left when building the baseline plan or when attempting to recover from a schedule slip. These techniques should be used cautiously with a strong focus on ensuring that the resulting forecast schedule is achievable and consistent with solid engineering discipline.

Programs that manage to an accelerated schedule typically have a better chance achieving contract obligation. This is due to the fact that accelerating a schedule helps to counter Parkinson's Law (which states that humans will take as long as given to accomplish a task), removes subjective personal buffer, and instills a sense of urgency on executing program tasks.

Managing to an accelerated schedule requires more discipline, adherence to the program battle rhythm, and strong leadership skills in removing obstacles to performance success.

Description

The following table (Figure 9.1.3-1) contains six examples of schedule acceleration techniques for application.

Technique	Description	Caution
1. Crashing	This technique allows for the acceleration of schedule by applying more resources to do the work in a shorter period of time. This method assumes that the task can be completed in a shorter amount of time with the increase in resources. Remember, it costs more money to add resources, ensure that the program funding profile supports the acceleration.	It costs more to add resources / validate funding profile works with the accelerated plan
2. Fast Tracking	This technique accelerates the plan by performing work in parallel. With this method extra attention needs to be put on resource de-confliction to ensure resources are not over allocated.	Pay attention to resource de-confliction when pulling tasks in parallel / avoid over allocating resources
3. Streamlining	This technique depends on the team's ability to find an alternate and more efficient completion methodology for the task/s. This includes reuse, innovation, and possibly eliminating non-value-added work. With this method, the program has to weigh the level of potential risk involved with these choices. Make sure that this does not drive a "run to fail" mode on the program. Ensure that tasks are meeting the full requirements and scope.	Carefully gauge level of risk in alternate task completion methodologies / don't "run to fail"

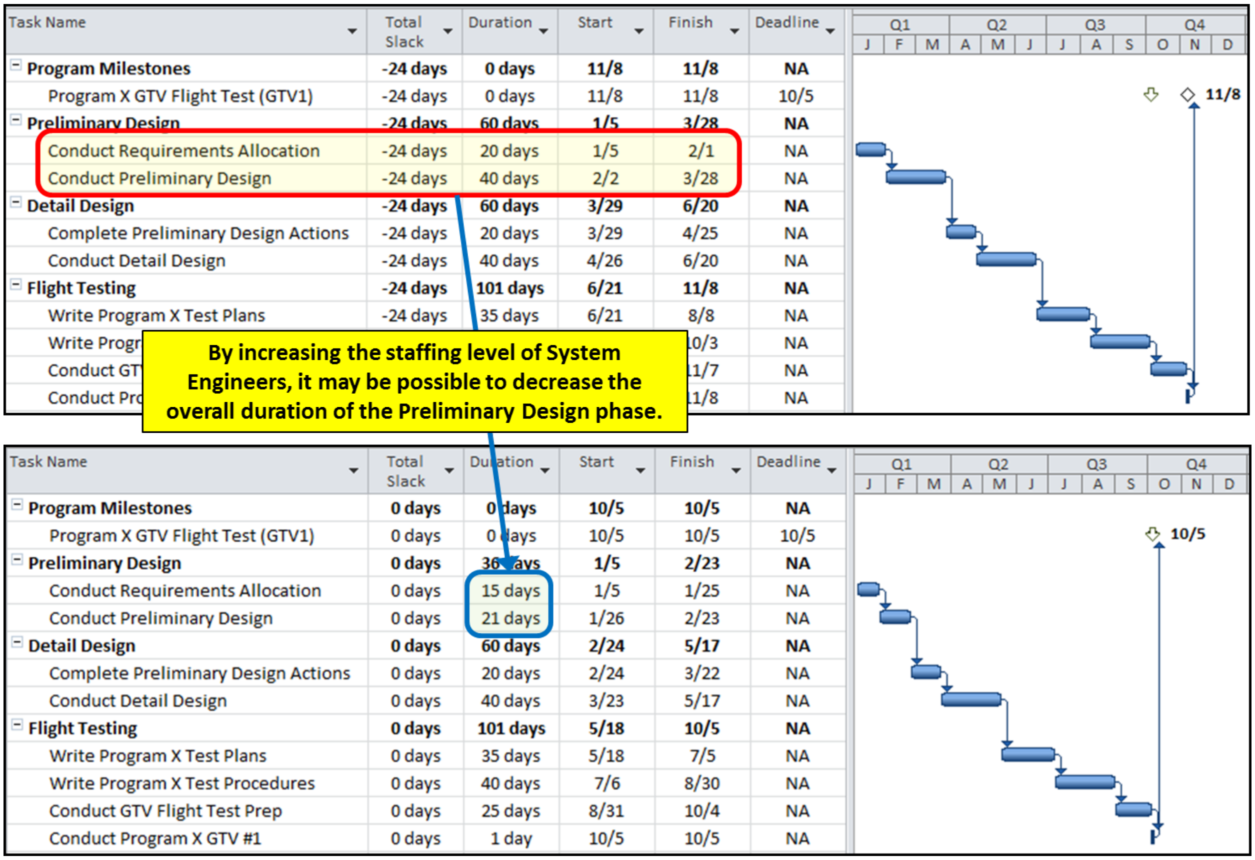
Technique	Description	Caution
4. Focused Work	This technique employs the program management team to help in reducing multitasking and to remove barriers for the personnel on the program that are working critical and near critical program tasks. This method requires the program culture to adapt and “protect the critical/driving path” and to support the people that are working those efforts. This also requires the program manager to perform daily barrier resolution.	Requires program culture shift to “protect the critical/driving path” and daily barrier resolution by PMs. Pay attention to float reduction trends in other areas of the schedule. Otherwise, the program critical/driving paths may be overtaken by items that don't have sufficient management focus.
5. Calendar Adjustments	This technique accelerates the plan by changing the amount of working hours available each day or working days available each week. This method is possible only if the resources and task location support working the increased work periods. Attention needs to be put on resource de-confliction to ensure resources are not over allocated.	Pay attention to resource de-confliction when pulling tasks in parallel / avoid over allocating resources
6. Delay or De-scope Effort	If other techniques are not a viable option and the resultant schedule delay impact is unacceptable, an option exists to propose delaying or removing the selected scope.	This selection may require a contractual change. This technique is the least preferred and should be avoided if at all possible.

Figure 9.1.3-1 Table of Methods available for Schedule Acceleration

Examples

1. Crashing

- Add more resources



Task Name	Total Slack	Duration	Start	Finish	Deadline
Program Milestones	**-24 days**	**0 days**	**11/8**	**11/8**	**NA**
Program X GTV Flight Test (GTV1)	-24 days	0 days	11/8	11/8	10/5
Preliminary Design	**-24 days**	**60 days**	**1/5**	**3/28**	**NA**
Conduct Requirements Allocation	-24 days	20 days	1/5	2/1	NA
Conduct Preliminary Design	-24 days	40 days	2/2	3/28	NA
Detail Design	**-24 days**	**60 days**	**3/29**	**6/20**	**NA**
Complete Preliminary Design Actions	-24 days	20 days	3/29	4/25	NA
Conduct Detail Design	-24 days	40 days	4/26	6/20	NA
Flight Testing	**-24 days**	**101 days**	**6/21**	**11/8**	**NA**
Write Program X Test Plans	-24 days	35 days	6/21	8/8	NA
Write Progr				0/3	NA
Conduct GT				1/7	NA
Conduct Pr				1/8	NA

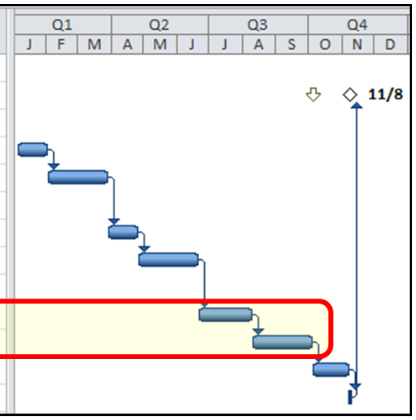
Task Name	Total Slack	Duration	Start	Finish	Deadline
Program Milestones	**0 days**	**0 days**	**10/5**	**10/5**	**NA**
Program X GTV Flight Test (GTV1)	0 days	0 days	10/5	10/5	10/5
Preliminary Design	**0 days**	**36 days**	**1/5**	**2/23**	**NA**
Conduct Requirements Allocation	0 days	15 days	1/5	1/25	NA
Conduct Preliminary Design	0 days	21 days	1/26	2/23	NA
Detail Design	**0 days**	**60 days**	**2/24**	**5/17**	**NA**
Complete Preliminary Design Actions	0 days	20 days	2/24	3/22	NA
Conduct Detail Design	0 days	40 days	3/23	5/17	NA
Flight Testing	**0 days**	**101 days**	**5/18**	**10/5**	**NA**
Write Program X Test Plans	0 days	35 days	5/18	7/5	NA
Write Program X Test Procedures	0 days	40 days	7/6	8/30	NA
Conduct GTV Flight Test Prep	0 days	25 days	8/31	10/4	NA
Conduct Program X GTV #1	0 days	1 day	10/5	10/5	NA

Figure 9.1.3-2 Example of Crashing

2. Fast Tracking

- Do work in parallel

Task Name	Total Slack	Duration	Start	Finish	Deadline
Program Milestones	**-24 days**	**0 days**	**11/8**	**11/8**	**NA**
Program X GTV Flight Test (GTV1)	-24 days	0 days	11/8	11/8	10/5
Preliminary Design	**-24 days**	**60 days**	**1/5**	**3/28**	**NA**
Conduct Requirements Allocation	-24 days	20 days	1/5	2/1	NA
Conduct Preliminary Design	-24 days	40 days	2/2	3/28	NA
Detail Design	**-24 days**	**60 days**	**3/29**	**6/20**	**NA**
Complete Preliminary Design Actions	-24 days	20 days	3/29	4/25	NA
Conduct Detail Design	-24 days	40 days	4/26	6/20	NA
Flight Testing	**-24 days**	**101 days**	**6/21**	**11/8**	**NA**
Write Program X Test Plans	-24 days	35 days	6/21	8/8	NA
Write Program X Test Procedures	-24 days	40 days	8/9	10/3	NA
Conduct GTV Flight Test Prep	-24 days	25 days	10/4	11/7	NA
Conduct Program X GTV #1	-24 days	1 day	11/8	11/8	NA



By writing the Test Procedures concurrently with the Test Plans, it may be possible to decrease the overall duration of the Flight Testing phase.

Task Name	Total Slack	Duration	Start	Finish	Deadline
Program M				**9/20**	**NA**
Progran				9/20	10/5
Preliminar				**3/28**	**NA**
Conduc				2/1	NA
Conduct Preliminary Design	11 days	40 days	2/2	3/28	NA
Detail Design	**11 days**	**60 days**	**3/29**	**6/20**	**NA**
Complete Preliminary Design Actions	11 days	20 days	3/29	4/25	NA
Conduct Detail Design	11 days	40 days	4/26	6/20	NA
Flight Testing	**0 days**	**77 days**	**6/21**	**10/5**	**NA**
Write Program X Test Plans	11 days	35 days	6/21	8/8	NA
Write Program X Test Procedures	11 days	40 days	6/21	8/15	NA
Conduct GTV Flight Test Prep	11 days	25 days	8/16	9/19	NA
Conduct Program X GTV #1	11 days	1 day	9/20	9/20	NA

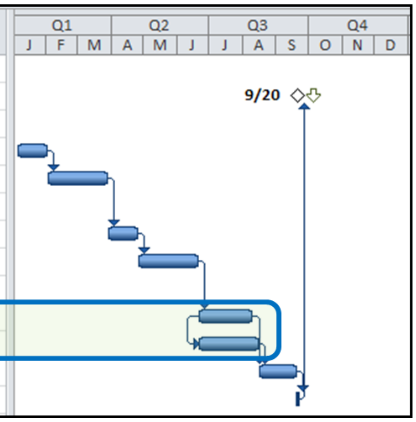
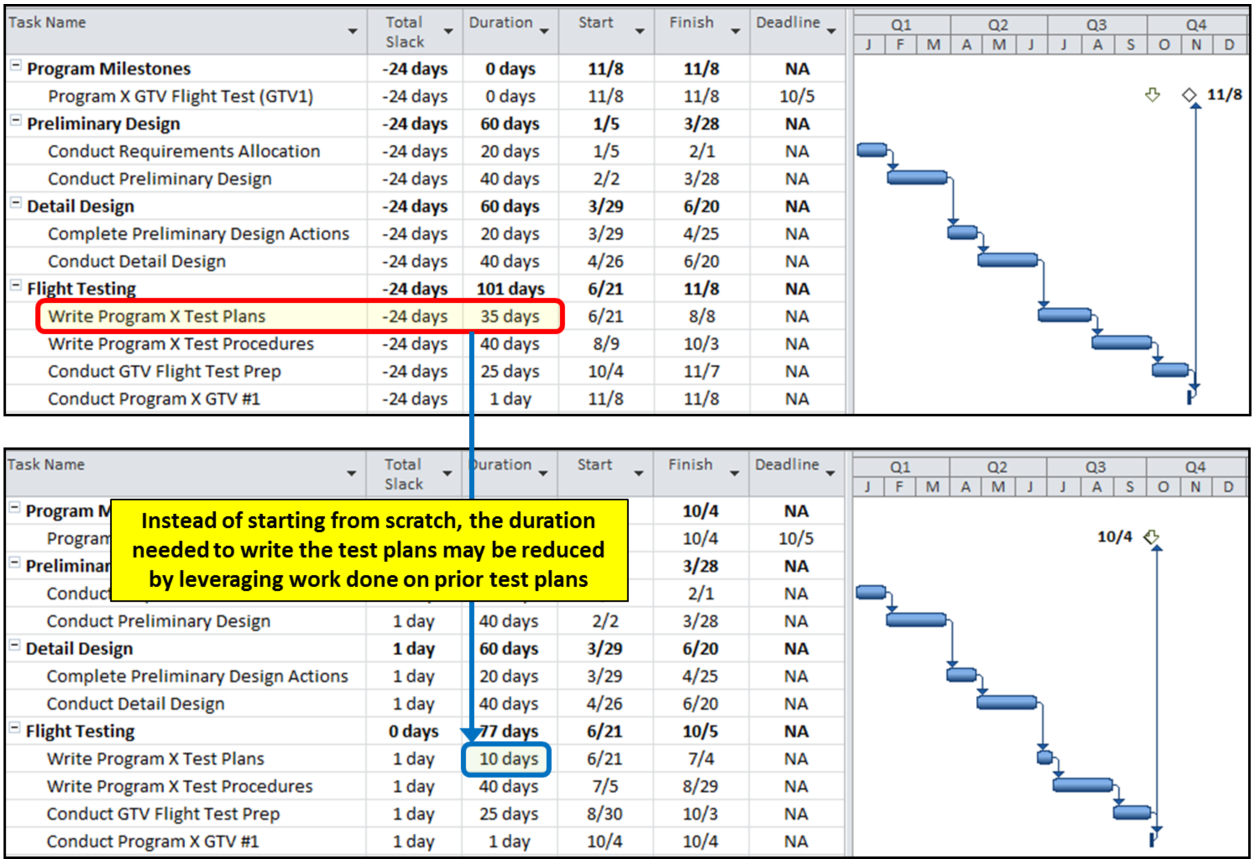


Figure 9.1.3-3 Example of Fast Tracking

3. Streamlining

- Implement a more efficient task completion methodology



Task Name	Total Slack	Duration	Start	Finish	Deadline
Program Milestones	**-24 days**	**0 days**	**11/8**	**11/8**	**NA**
Program X GTV Flight Test (GTV1)	-24 days	0 days	11/8	11/8	10/5
Preliminary Design	**-24 days**	**60 days**	**1/5**	**3/28**	**NA**
Conduct Requirements Allocation	-24 days	20 days	1/5	2/1	NA
Conduct Preliminary Design	-24 days	40 days	2/2	3/28	NA
Detail Design	**-24 days**	**60 days**	**3/29**	**6/20**	**NA**
Complete Preliminary Design Actions	-24 days	20 days	3/29	4/25	NA
Conduct Detail Design	-24 days	40 days	4/26	6/20	NA
Flight Testing	**-24 days**	**101 days**	**6/21**	**11/8**	**NA**
Write Program X Test Plans	-24 days	35 days	6/21	8/8	NA
Write Program X Test Procedures	-24 days	40 days	8/9	10/3	NA
Conduct GTV Flight Test Prep	-24 days	25 days	10/4	11/7	NA
Conduct Program X GTV #1	-24 days	1 day	11/8	11/8	NA

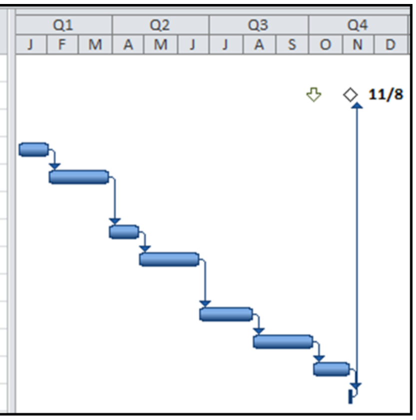
Task Name	Total Slack	Duration	Start	Finish	Deadline
Program M				**10/4**	**NA**
Program				10/4	10/5
Preliminar				**3/28**	**NA**
Conduct				2/1	NA
Conduct Preliminary Design	1 day	40 days	2/2	3/28	NA
Detail Design	**1 day**	**60 days**	**3/29**	**6/20**	**NA**
Complete Preliminary Design Actions	1 day	20 days	3/29	4/25	NA
Conduct Detail Design	1 day	40 days	4/26	6/20	NA
Flight Testing	**0 days**	**77 days**	**6/21**	**10/5**	**NA**
Write Program X Test Plans	1 day	10 days	6/21	7/4	NA
Write Program X Test Procedures	1 day	40 days	7/5	8/29	NA
Conduct GTV Flight Test Prep	1 day	25 days	8/30	10/3	NA
Conduct Program X GTV #1	1 day	1 day	10/4	10/4	NA

Figure 9.1.3-4 Example of Streamlining

4. Focused Work

- Stop multitasking / remove barriers

Task Name	Total Slack	Duration	Start	Finish	Deadline
Program Milestones	**-24 days**	**0 days**	**11/8**	**11/8**	**NA**
Program X GTV Flight Test (GTV1)	-24 days	0 days	11/8	11/8	10/5
Preliminary Design	**-24 days**	**60 days**	**1/5**	**3/28**	**NA**
Conduct Requirements Allocation	-24 days	20 days	1/5	2/1	NA
Conduct Preliminary Design	-24 days	40 days	2/2	3/28	NA
Detail Design	**-24 days**	**60 days**	**3/29**	**6/20**	**NA**
Complete Preliminary Design Actions	-24 days	20 days	3/29	4/25	NA
Conduct Detail Design	-24 days	40 days	4/26	6/20	NA
Flight Testing	**-24 days**	**101 days**	**6/21**	**11/8**	**NA**
Write Program X Test Plans	-24 days	35 days	6/21	8/8	NA
Write Program X Test Procedures	-24 days	40 days	8/9	10/3	NA
Conduct GTV Flight Test Prep	-24 days	25 days	10/4	11/7	NA
Conduct Program X GTV #1	-24 days	1 day	11/8	11/8	NA



If management actively breaks down barriers, workers stop multitasking, and priority is given to "critical tasks", overall duration may be reduced

Task Name	Total Slack	Duration	Start	Finish	Deadline
Program Milestones					**NA**
Program X GTV Flight Test (GTV1)	0 days	0 days	10/5	10/5	10/5
Preliminary Design	**0 days**	**53 days**	**1/5**	**3/17**	**NA**
Conduct Requirements Allocation	0 days	18 days	1/5	1/28	NA
Conduct Preliminary Design	0 days	35 days	1/29	3/17	NA
Detail Design	**0 days**	**53 days**	**3/18**	**5/31**	**NA**
Complete Preliminary Design Actions	0 days	18 days	3/18	4/12	NA
Conduct Detail Design	0 days	35 days	4/13	5/31	NA
Flight Testing	**0 days**	**91 days**	**6/1**	**10/5**	**NA**
Write Program X Test Plans	0 days	30 days	6/1	7/12	NA
Write Program X Test Procedures	0 days	35 days	7/13	8/30	NA
Conduct GTV Flight Test Prep	0 days	25 days	8/31	10/4	NA
Conduct Program X GTV #1	0 days	1 day	10/5	10/5	NA

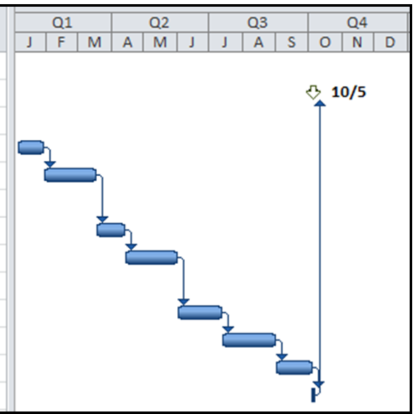


Figure 9.1.3-5 Example of Focused Work

Things to Promote

Proactive management involvement and support of this process

Use any mix of the techniques to accelerate the schedule as they apply to the different types of tasking.

Ensure to continuously monitor and assess the increased risk versus gain when seeking to accelerate the IMS. The resulting accelerated schedule should always be executable and aligned with programmatic requirements.

Perform all acceleration analysis in a copy of the IMS. This ensures you can recover to the latest IMS if the acceleration analysis yields results not accepted by the program.

Be cognizant of the program's funding profile. Communicate potential changes to the funding profile to the customer to see if they will adapt funding to promote the acceleration.

Use the most recent IMS to conduct acceleration analysis. This ensures the results of schedule acceleration will not be overcome by the missing status.

Things to Avoid

Validate that resources are not being over allocated through the acceleration process. Over allocation of resources will not support successful acceleration and will cause the tasking to slip.

Try not to introduce additional risk while accelerating the tasking.

Ensure that the task scope is still being met once the acceleration is applied.

Schedule acceleration is not always possible and structuring an IMS in a fashion that is unachievable in order to present an "on time" forecast is unacceptable.

Avoid repeated and unsuccessful efforts to accelerate the schedule. This may be indicative of an overall schedule which is not realistic.

Related Topics

Schedule Risk Assessment (SRA) - Setup and Execution
Incorporation of Risk and Opportunities
Statusing to Time Now
Forecasting

9.1.4 Estimate at Completion

Manager's View

The Estimate at Completion (EAC) is the estimated total cost of all authorized work. The EAC includes all actual costs incurred to date plus the estimated cost to complete all remaining work. The Estimate to Complete (ETC) is the component of the EAC that is an input to the EVMS and as such will be the primary focus of this section.

Accurate EAC/ETC information is fundamental to successful program management and performance reporting. Given that the IMS should accurately reflect all work required to complete the program, the ETC should align with, and the expected case be derived from, the forecasted tasking in the IMS model.

Description

The Cost and Schedule Integration section of this guide discusses resource loaded v. non-resource loaded schedules and the benefits and limitations of each. A relevant point from that section is that ETC information from the schedule should be in alignment with ETC information in the cost system. This includes the time phasing of the resources and the total amount or quantity of resources. In native field implementation of a resource-loaded schedule, this alignment is inherent to the cost-schedule integration process.

IMS maintenance requires that on a regular basis, at least monthly, the schedule is updated to Time Now to reflect the state of the program. The status cycle records actual start and finish dates, remaining durations for in-progress tasks, percent complete assessed for Earned Value purposes, and in a resource loaded schedule, the remaining work (ETC) is estimated. The ETC alignment with the schedule is automatic using the native fields of the scheduling software to assign resources to tasks. For non-resource loaded schedules, the status process should include a separate ETC estimating process that ensures IMS alignment as described in the Cost Schedule Integration section.

Using the IMS as the basis for the ETC will provide the most detailed and accurate information available to program/IPT management. A resource loaded IMS enables integrated evaluation of resource availability and capacity issues across the program or enterprise. It also simplifies the ability to include resource and cost implications to "What-if" program analysis.

Note: Including accurate resource rates, in addition to prime elements, in a resource loaded schedule enhances the capability of the IMS to assist in ETC analysis. However, it is important to understand the impacts of maintaining rates in the IMS as there are proprietary and rate change implications to consider.

Example

This is an example (Figure 9.1.4-1) of a resource-loaded schedule. ETC alignment with the schedule is inherent because the native fields of the software are used.

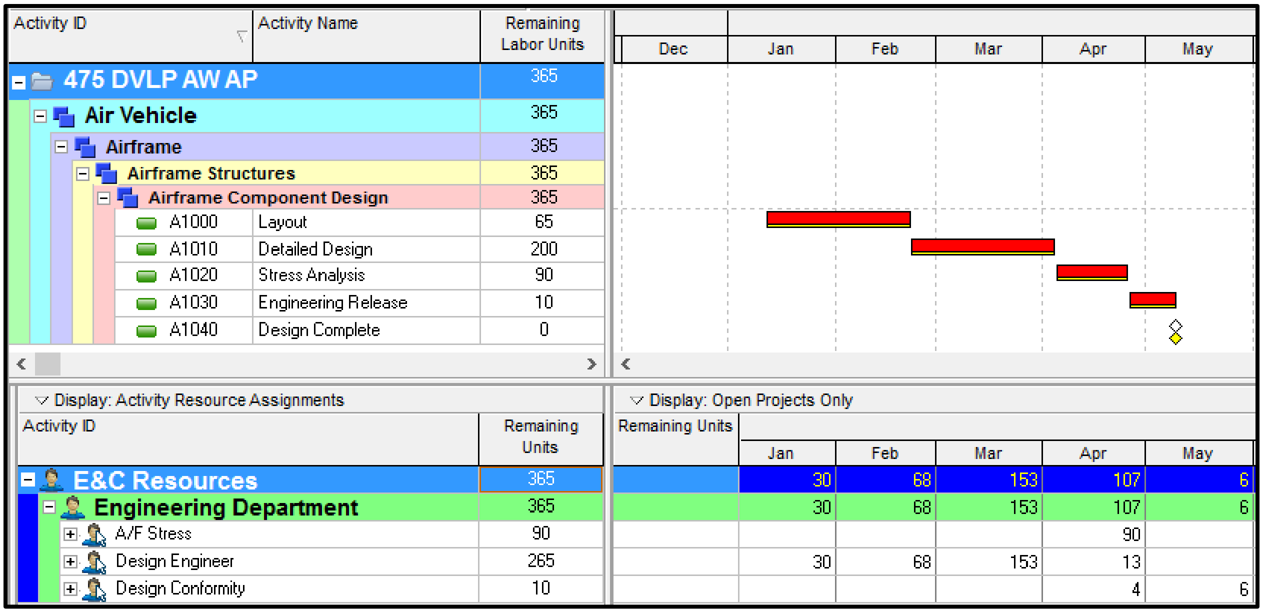


Figure 9.1.4-1 Example of a Resource loaded IMS using Native field resource loading

Calculations

EAC = ACWP + ETC

EAC = Estimate at Completion
ACWP = Actual Cost of Work Performed, may also be known as Actual Cost (AC)
ETC = Estimate to Complete

The IMS is the basis for the ETC period of performance. When using a resource loaded schedule, the IMS can serve as the basis for all aspects of the ETC. When using a non-resource loaded source for the ETC, care should be taken to ensure that alignment for both dates (baseline and forecast) and resources (baseline resources and forecast resources) are in alignment with the data in the IMS.

Things to Promote

Resource loaded schedules enable automation of ETC data transfer from scheduling systems to EVM Systems to eliminate redundant effort and/or human error in data transfer.

Program should periodically validate that data in the Finance Tool remains in sync with the data in the schedule (IMS) as the differences in calendars, Finance Tool import options and user error in tasks selection may result in data provided by the IMS to not be accepted by the Finance tool.

Resources are budgeted at the Work Package level of the WBS. Therefore, programs should validate dates and resources at the Work Package level, at a minimum.

Use of EVM cost metrics such as Cost Variance (CV), Cost Performance Index (CPI), and To Complete Performance Index (TCPI) to gauge realism of EAC projections.

Things to Avoid

Avoid developing an EAC without ETC information that is directly traceable to and supported by the forecast tasking in the IMS model.

Avoid allowing the system to automatically estimate the work remaining without CAM review and approval.

Related Topics

- Resources in the Schedule
- Resources Not in the Schedule
- Statusing to Time Now
- Forecasting

9.2 Baseline Maintenance

This section contains the following chapters.

9.2.1 Baseline Change Management

Manager's View

The Baseline Change Management process provides a clear understanding of IMS revisions as they relate to the establishment and modifications of scope, schedule and budget distributions. When used correctly, the baseline change process clearly traces changes with appropriate supporting documentation and approvals. However, without a clearly documented baseline change process, or worse, no baseline change process at all, configuration control of the IMS is impossible. Additionally, without a dependable baseline change process, management and other consumers of the IMS information have no way of understanding changes made to the IMS. This loss of configuration control influences management's confidence in the IMS and the ability to use it to manage the program.

Description

Utilize Baseline Change Requests (BCRs) as a means of IMS baseline configuration control by documenting approved changes to the baseline. The change process establishes a clear definition of required documentation to support changes to the program and the impact to the IMS. Include the following items in BCR documentation; justification, BCR type, impacted tasks, duration, resources required to implement change and the existing condition of these elements prior to the change. Specifically, the documentation should reference the CAMs (task owners), control accounts, WBS elements, OBS elements, budget amounts and net impact to program milestones. The BCR process defines the managing Program Team for approvals, along with documented disposition for incorporation into the IMS.

Incorporating baseline changes is one of the most time consuming and complicated steps in maintaining an IMS. The process covers everything from small tactical baseline changes to full global reprogramming efforts. As such, the program team should strictly follow a detailed business rhythm defining the BCR steps. Ensure the BCR business rhythm is scalable and includes sufficient time to perform quality control and pre/post cost and schedule impact analysis. This will help to facilitate the timely and accurate implementation of baseline changes.

Types of BCRs include:

Contract Baseline Changes

Contract Baseline Changes provide traceability into customer driven contract changes. BCR documentation includes changes to SOW (additions, changes or deletions) along with impact to key Program Milestones. Coding and unique fields allow for visibility into these changes for internal and external reviews.

Impacts due to Baseline revisions affecting cost, schedule and risk are critical when processing scope changes to align both customer and program team expectations.

Reprogramming

When the baseline is no longer executable and the IMS as a tool is ineffective, it may require a reprogramming - adjusting the baseline dates for executability. Reprogramming requires collaboration between both the contractor and customer, to produce an IMS that identifies all remaining efforts with alignment of Major Program Milestones. A comprehensive analysis of the program's path forward should be conducted prior to implementing a reprogram. The reprogramming may result in an Over-Target Schedule (OTS), a schedule that exceeds the contracted milestones. Reprogramming or an OTS does not affect the terms and conditions of the contract; all contractual milestones remain in effect. The new dates are for performance measurement purposes only. Supporting documentation and the BCR process that identifies changes to duration, logic, and resources is required when implementing changes. The DoD Over Target Baseline and Over Target Schedule Handbook provides additional information regarding reprogramming.

Internal Baseline Changes

Use Internal Baseline Changes to document internal or non-contractual changes to the IMS baseline. These changes include but are not limited to, rolling wave planning and replanning of tasks and resources in the future based on a new understanding of program goals, constraints or execution strategy. BCR documentation for internal baseline changes should identify changes in duration, logic, and resources in addition to deleted, changed, or added tasks. Internal changes should not be retroactive and should adhere to any “freeze” period (i.e., period of time when baseline changes are not allowed) that the contractor may have in place. Prohibiting retroactive changes helps maintain the fidelity of the baseline and ensures performance measurement against the plan that was in place at the time of execution. The exception to retroactive changes is for the correction of errors.

Administrative Schedule Changes

Administrative schedule changes do not affect the distribution of BCWS and include the addition and deletion of milestones or Schedule Visibility Tasks (SVTs) and the correction or clarification of task names.

Document and maintain these types of schedule changes in a configuration-controlled process. Typically, administrative schedule changes do not require the level of detail or management approval prior to implementation as compared to Baseline Changes affecting BCWS distribution. See section on Schedule Visibility Tasks.

Things to Promote

Use unique BCR numbers for each change made to the IMS baseline. Using a BCR field in the IMS, capture these unique BCR numbers on impacted tasks in the IMS as a means of ensuring traceability back to the BCR documentation.

BCR documentation should be easily traceable, provide a clearly identified timeframe, identify downstream and scope impacts, and be part of a controlled approval process.

BCR documentation should include data that depicts changes to both the IMS and the Performance Measurement baseline.

Ensure open collaboration between the contractor and customer on baseline changes that impact or alter program execution

Ensure all stakeholders clearly understand the cost and schedule impacts of significant BCRs.

Ensure to include changes to the IMP and/or WBS during the baseline maintenance process. This may require contractual coordination with the customer.

BCRs will likely require adding and deleting tasks in addition to making changes to in-process tasks. There are many alternative methods to implementing BCRs on in-process tasks including closing the in-process task and reopening a new task with the remaining scope or simply documenting the change to the remaining scope of the in-process task. Ensure all IMS stakeholders clearly understand and consistently apply the chosen method of changing in-process tasks.

Ensure to consider contractual and internally defined commitment dates when incorporating baseline changes to avoid unintended downstream impacts.

Ensure the program team understands the difference between managing forecast task characteristics (duration, logic, resource allocation, date constraint application) versus baseline maintenance, eliminating any confusion surrounding normal active schedule task management.

Explain a retroactive change, due to a correction of an error, in the BCR (Baseline Change Request) documentation. Retroactive changes for this purpose may still require notification to the customer.

Things to Avoid

Avoid incorporating changes, which influence metrics or mask performances variances or retroactive changes to the baseline schedule, in order to improve historical metric performance.

BCRs allow the IMS to represent an accurate model of the program plan. Baseline changes which are poorly defined and do not have substance often put the program at risk for having a "rubber baseline" (i.e. one that changes frequently and/or continuously) or an IMS that cannot be effectively used as a management tool. Effective process control is necessary to ensure baseline and forecast integrity as a predictive model for program execution.

Avoid BCR scope changes that are initiated for any reasons other than through contractual changes.

Related Topics

Rolling Wave Planning
Vertical Integration and Traceability
Managing using the IMS
Schedule Visibility Tasks (SVT)

9.2.2 Rolling Wave Planning

Manager's View

Rolling Wave planning is an incremental approach that helps program management focus on more immediate work with a detailed schedule and far term schedules planned at a higher level until the program better understands the details about the scope, cost and delivery requirements of that effort. As the program progresses and requirements are refined, the program extends the detailed schedule into the future as a 'rolling wave' of planning. This concept allows program personnel to provide clarity where needed while saving unnecessary time and expense developing plans where details cannot be clearly defined. Rolling Wave planning can be especially beneficial to programs where the Statement of Work (SOW) is likely to change.

Description

The Rolling Wave concept pulls together two schedule development approaches; Top-down and bottom-up planning. Top-down planning is the process of breaking down into detail a schedule starting with the major milestones. For example, a schedule based on an RFP with desired review and delivery dates can be broken down into summary schedules to support those milestones. Because the full scope of the effort is undefined, these schedules provide a framework for the program but recognize that more information from the review process is necessary to provide specifics for the work. Additionally, programs can employ bottom-up planning when the program knows that detail. Armed with this knowledge, the program can define the specific tasks, durations, relationships and resources to complete the work. The goal of the rolling wave planning exercise is to balance the framework of the scope, date and cost requirements of the top-level plan with the organization's capabilities and the specific requirements in the detailed plan. The program can then extend the detail plan into the future, as the program understands additional information about the program goals and requirements.

In rolling wave planning, the IMS usually contains near term detailed information in work packages. These work packages are composed of one or more IMS tasks, are shorter in duration, and have necessary logic ties to all other tasks. Additionally, these elements are either resource loaded or linked to resource and cost budgets in other management systems. These work packages represent a specific plan for accomplishing the near term program goals and, in an EVM System, are the basis for the time-phased Performance Measurement Baseline (PMB) and the Estimate to Complete (ETC). They also have assigned earned value measurement techniques to provide performance measurement against the plan for analysis and issue resolution.

For planning outside of the Current Detail Plan Period, Planning Packages represent work defined at a higher level of detail. Planning Packages have almost all the same characteristics of work packages. Their average durations may be longer than detail tasks, but like detail tasks, they also have logical relationships with other tasks in the IMS so a Critical Path may be determined. They have associated resource cost budgets and forecasts to support the scope they represent, providing that information in the EVM System to maintain the PMB and forecast. However, because Planning Packages lack sufficient detail for measured progress, EVM performance data is limited until the detailed planning is available.

During the initial development phase of a new program, the program establishes detailed work packages for the first phase of the program and planning packages for the remaining effort. How far into the future work packages are planned is determined by several factors including; event phasing, program risk level, quality of the requirements, experience with similar programs and common sense. However, a balance should be struck between having enough accurate detail in the current 'planning horizon' to manage the program without extending the detailed planning so far out in time that changes to the plan are frequently required to keep it relevant.

To help provide guidance for determining the period of the planning horizon, the program effort is usually detail planned to the next program phase, major milestone, or event. This approach allows the schedule to develop based upon increased understanding of the requirements discovered during the progression of the program. In the initial program phase, the planning windows tend to be shorter during the requirements definition and design review phases and grows longer as the program matures into the development and deployment phases.

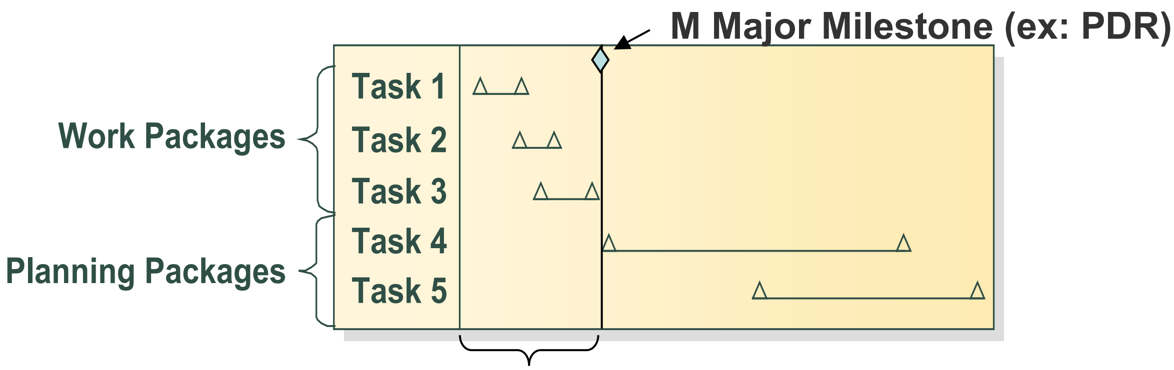


Figure 9.2.2-1 Detail Planning Window

Before the first planning window ends, the process of developing the next period of detail begins. Programs should precede rolling wave exercises with instructions to the participants for goals and expectations of the exercise. These instructions usually contain the duration of the next planning window, quality discussions, an implementation schedule, methods of integration, and a schedule of management review meetings necessary to assure a smooth transition to the next level of schedule development. Program should repeat this process as necessary throughout the life cycle of the program.

In some cases, programs implement rolling wave planning based not on Event-to-Event gates but upon other increments such as revisions, updates or blocks. This approach, referred to as Block Planning, describes the increasing detail of the schedule based upon logical building blocks of information. While not all blocks contain the exact information, they are similar in structure to each other. For example, software block planning may have different features as the goal of each block. This creates minor variations in each block when detailed from planning packages to work packages, but the basic structure for updating the particular block revision is the same.

In other cases, programs cannot easily align its detail-planning window with periodic IMP Events or Major milestones or the time between Events or Milestones may be greater than practical planning can support. To address these situations, the detail-planning window could extend to a relevant defined period, rather than the conclusion of an IMP Event or major milestone.

For example, if the minimum level of detail is 3 months, then the program may decide to plan for 6-month intervals and conduct rolling wave exercises every 3 months until conditions change or the program ends.

Example

An example of a 3-month rolling wave:

At the beginning of the effort, only three months are detail planned as shown in Figure 9.2.2-2.

To maintain the 3-month look-ahead in the IMS, the Planning Package represented by Task 4 in Figure 9.2.2-2 is detail planned to detailed Tasks 4-6 as shown in Figure 9.2.2-3.

Task 7 in Figure 9.2.2-3 captures the remainder of the Planning Package Period of Performance and budget, allowing decomposition into detailed tasking later, though the program may choose to detail these details now if sufficient knowledge of the details exists.

Task Name	EVT	Start	Finish
Rolling Wave - BEFORE		**2/1**	**9/9**
Task 1	Discrete	2/1	2/29
Task 2	Discrete	3/1	3/31
Task 3	Discrete	4/1	4/29
Task 4	Planning Pkg	5/2	9/9

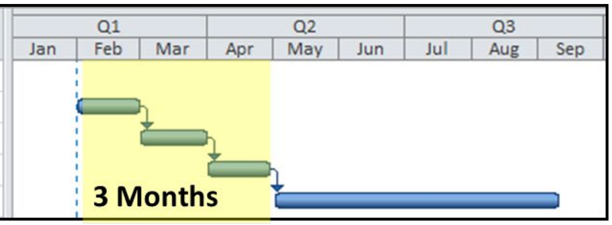


Figure 9.2.2-2 Three months of detail tasking and a Planning Package.

Task Name	EVT	Start	Finish
Rolling Wave - AFTER		**2/1**	**9/9**
Task 1	Discrete	2/1	2/29
Task 2	Discrete	3/1	3/31
Task 3	Discrete	4/1	4/29
Task 4	Discrete	5/2	5/31
Task 5	Discrete	6/1	6/30
Task 6	Discrete	7/1	7/29
Task 7	Planning Pkg	8/1	9/9

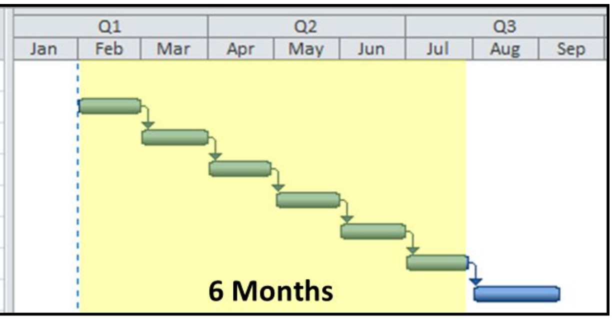


Figure 9.2.2-3 After detailing Task 4 in Figure 9.2.2-2, we have 6 months of discrete tasking and a newly created Planning Package for the balance of the Period of Performance.

Things to Promote

Find a balance between enough near-term detailed planning to be managerially useful but not so far out in the future to require constant changing.

Use documentation with a level of fidelity similar to the “Basis of Estimate (BOE)” in the proposal phase as part of the BCR process.

Periodically review the planning horizon over the life of the program to determine if the rolling wave methodology still meets the program needs. Consider using different planning windows on different aspects of the program depending on baseline volatility.

During the rolling wave, CAMs should re-evaluate all work within the wave, not just the new work planned.

Programs should break down Planning Packages that are on or near the Critical Path/Driving Path or carry a high degree of risk into smaller elements to facilitate schedule analysis and risk mitigation.

Detail plan beyond the rolling wave period if possible and reasonable.

Ensure that the appropriate program stakeholders participate in the Rolling Wave process and validate the resultant detail plan to help garner buy-in and ownership.

When decomposing Planning Packages into task details ensure you also consider their impact to the total program IMS. Use sound, logical relationships that accurately represent the total program’s workflow.

Things to Avoid

Avoid permitting work to remain in planning packages during the current accounting period.

Avoid establishing tasks in the planning window without network logic.

Avoid artificially “cutting off” tasks to finish at the end of the rolling wave or detail planning window. Work Packages can be detail planned outside of the rolling wave window or detail planning window.

Avoid incorporating out of scope changes into the PMB during a Rolling Wave process, without considering contractual implications.

Avoid reducing durations of planning packages to hold end dates. While they are not fully detailed, Planning Packages should still contain realistic durations necessary to achieve the task.

Related Topics

Baseline Change Management
Top-Down v. Bottom-Up Planning
Horizontal Traceability
Vertical Integration and Traceability

10 Schedule Analysis

This section contains the following chapters.

10.1 Critical and Driving Path Analysis

Manager's View

Critical Path Method (CPM) models a program network by capturing the duration and logical relationships of every program task. There are three basic elements of the Critical Path Method. They are the Forward Pass, the Backward Pass and the Float calculation. The PASEG utilizes the following definitions for Critical and Driving paths.

Critical Path = the longest continuous sequence of tasks from Time Now to the program end date. A delay to any task on the critical path should result in a corresponding delay to the project end date.

Near Critical Path(s) = the secondary, tertiary, etc. Critical Paths to the program end date.

Driving Path = the longest sequence of tasks from Time Now to an interim program milestone. If a task on a Driving Path slips, the forecasted interim program milestone date should slip.

Near Driving Path(s) = the secondary, tertiary, etc., Driving Paths to an interim program milestone.

Note: "near" driving paths are separately identifiable and may or may not intersect with the Driving Path.

Critical/Driving Paths may start to the right of Time Now if the driver to the path originates from any constrained task or milestone utilized as an input to the program schedule.

Critical/Driving path identification and analysis is essential to ensure that management is focusing on the correct tasks to prevent slippage of the program end date. Close monitoring and analysis of Critical and Near Critical Paths will ultimately provide management with the necessary insight to keep the program under control and on track for successful completion. The Critical and Driving paths are not static and can change as the program progresses.

Description

Critical Path Analysis is a network analysis technique used to predict program duration by analyzing which sequence of activities has the least amount of scheduling flexibility. The result of Critical Path analysis is the identification of the program's Critical and Driving Paths. To ensure the accuracy of this analysis, task owners should constantly validate the task durations and logical relationships (refer to the Forecasting chapter for additional information on IMS quality control).

Common characteristics of a credible Critical Path include the following:

- It begins at "time now" and proceeds to program completion or completion milestone (i.e., Final Deliverable)
- The tasks and milestones are tied together with sound network logic in a sequence that is programmatically feasible and makes sense from a workflow standpoint
- The path does not contain level-of-effort (LOE) or summary activities
- The path does not contain unexplained gaps in time between tasks, such as lags representing non-PMB effort
- The initial and subsequent changes to the critical path are concurred to by senior program leadership

Example

The following example (Figure 10.1-1) represents a program Critical Path.

Task Name	Duration	Start	Finish	Total Slack
Main Fuselage Assembly	15 days	1/25	2/12	-3 days
Aircraft Mate	15 days	2/15	3/4	-3 days
Final Aircraft Assembly	30 days	3/7	4/15	-3 days
Conduct Functional Test	10 days	4/18	4/29	-3 days
Ground Run	5 days	5/2	5/6	-3 days
First Flight	0 days	5/6	5/6	-3 days
Flight Operations	35 days	5/9	6/24	-3 days
Customer Acceptance Flights	5 days	6/27	7/1	-3 days
Final Aircraft Checkout	2 days	7/4	7/5	-3 days
Aircraft DD250	0 days	7/5	7/5	-3 days

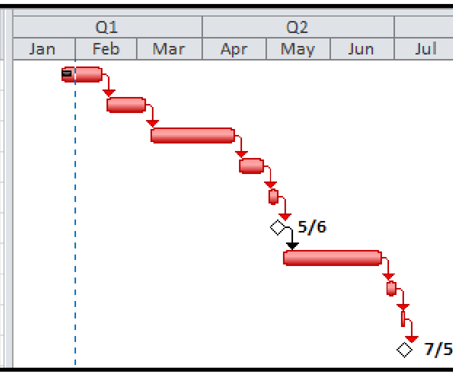


Figure 10.1-1 Example of a Program Critical Path

Calculations

Schedule Calculation Algorithm

Forward Pass: calculates the early dates
Backward Pass: calculates the late dates
Total Float: difference between the early and late finish date

Identifying Paths

The methodologies necessary to identify and display critical and driving paths are largely dependent on the:

- Health of the IMS network (i.e. appropriate and complete use of logic, lags/leads, duration, and constraints).
- Scheduling software.
- Configurable options within the scheduling software.

Some of the major schedule software tools have the ability to identify and display critical and driving paths. Additionally, there are many options available for add-in/bolt-on tools that work with the schedule software to assist in this analysis.

The manual method of identifying critical and driving paths typically involves:

- The temporary use of a constraint that impacts the "late" dates on the interim milestone or program end.
- A combination of sorting, filtering, grouping, and logic trace backs to identify and flag the path in question.

Optional Techniques

Unconstrained Critical Path Method

An alternative management approach is to implement the unconstrained Critical Path Method (CPM) in which the program consistently applies its primary focus to the contract end date. This requires some alternative methods of schedule management. In unconstrained CPM there are no constraints placed on task or milestone late dates. This means that there will never be a negative Total Float value calculated in the IMS. The tasks on the Critical Path will always have a Total Float/Slack value of zero. The calculated Total Float value on the non-critical path tasks will then always indicate the amount of flexibility the task has before it affects the contractual end date.

Important things to consider when implementing unconstrained CPM:

- In unconstrained CPM, the Total Float value does not indicate the program's position against contractually required dates as the Total Float calculation is ONLY in reference to the program's end. To mitigate this situation schedule management teams should capture the contractually required dates in the baseline or an alternative static date field and calculate the variance between it and the most recent forecasted early dates. The resulting variance will indicate the program's position against contractually required dates. Note: Ensure that the variance formula calculates working days versus calendar days.
- Ensure that all program stakeholders (to include the program team, senior executives, customers, and auditors) fully understand and accept the program's decision to manage via unconstrained CPM. It will be necessary to explain in detail the idiosyncrasies of how Total Float and contractual date variances management process with all stakeholders of the IMS. If all stakeholders on the program have the same understanding, this will ensure that accurate, consistent conclusions are drawn as they perform schedule analysis from their own perspectives

Unconstrained CPM may not be an appropriate use on programs where the primary objective is to demonstrate remaining effort to the program completion (i.e. delivering real time incremental capability to war fighters in the field).

Probabilistic Critical Path(s)

Probabilistic paths are those that have a high probability to grow to become the longest path due to technical/schedule risk and have been planned with total float or schedule margin to account for the expected schedule growth.

Things to Promote

Your process should ensure that management has insight into the Critical and Near Critical paths to enable accurate decision making for program success. It is important that the program team know and understand where the schedule has flexibility, and where it does not.

The program team's confidence in the IMS is essential. Confidence will only materialize if senior program leadership ambitiously supports managing to the IMS by holding all program personnel accountable for schedule data and requiring task owners to provide consistent and accurate inputs to the model.

Understand and consistently apply the configurable scheduling software options.

Set the bar high in the assessment of a schedules condition and its execution.

Uphold sound schedule management practices / processes and instill a sense of accountability and ownership for schedule data. A poorly constructed schedule is a schedule management problem, not a schedule problem. A poorly constructed schedule is a result, not a cause.

Maintain robust Quality Control (QC) processes for schedule integrity. Attributes of a successful program schedule as defined by the GASP are that the schedule is:

- Complete
- Traceable
- Transparent
- Statused
- Predictive
- Usable
- Resourced

- Controlled

It is extremely important to note the difference between critical path activities and "critical activities" as defined by management or the schedule software tool. These two may be, but are not necessarily, the same. In scheduling terms, the critical path is the sequence of activities that are tied together with network logic that have the longest overall duration from time now until program completion. Critical activities are tasks having these distinctions assigned to them, identified as "crucial" activities in this guide.

Ensure that schedule analysis clearly communicates the program's current progress against contractual requirements.

Things to Avoid

Recognize / understand the consequences and pitfalls associated with:

- Maintaining negative total float in a schedule as it depicts a behind schedule position and can negatively influence task prioritization.
- Use of total float as a baseline variance measurement as Total Float is not calculated relative to the baseline position but relative to the program end.
- Ignoring and losing focus on Critical Path.
- The improper use of schedule construction options (i.e. constraints, lags, leads, etc.) as these uses could result in an inaccurate and ineffective IMS.
- Focusing the program team exclusively on the near-term milestone drivers and losing sight of the far term obligations.
- Avoid focusing only on Critical Path tasks and ignoring the rest of the schedule.

Related Topics

Schedule Calculation Algorithm
Managing using the IMS
Schedule Margin
Current Execution Index (CEI)

10.2 Schedule Health Assessment

Manager's View

Periodic schedule health assessments are essential to ensure the IMS is valid and effective for reporting on accomplishments and predicting future performance. The program leadership team needs to be aware of the health of the schedule used to execute the program. By implementing regular schedule health assessments and addressing issues identified in those assessments, program managers should be confident in using the schedule to manage the program. Programs should perform schedule health assessments not only during program execution but also throughout the IMS design and development process to ensure the integrity and the validity of the IMS data.

Description

A schedule health assessment is often a report (display or document) containing a defined set of data or statistics reviewed for compliance to a standard, threshold, or guideline. Schedule health assessments are primarily quantitative and address the Generally Accepted Scheduling Principles (GASP). In the IMS Supplemental Guidance, programs should document the procedures that state the frequency of schedule health assessments, weighting of data, and a defined set of exceptions to criteria (e.g. does not include summary tasks, LOE). Refer to the IMS Supplemental Guidance chapter in this guide.

Schedule health metrics are different from schedule execution metrics (see chapters on Schedule Execution Metrics for discussion of this topic). Schedule health metrics focus on the mechanics of the schedule to ensure it is a useful program planning and execution tool. The calculation section below includes a sample list of schedule health metrics. Schedule execution metrics focus on the performance of the program and include metrics such as Baseline Execution Index, Schedule Performance Index, and Current Execution Index.

Planner/Schedulers are often required to run schedule health assessments on a regular basis (at least monthly). Planners/Schedulers may have at their disposal a number of automated tools that will analyze the IMS in accordance with a commercially available Schedule Health Assessment tool or any user-generated criteria. Running these metrics regularly is essential to maintaining an accurate IMS. The schedule health assessment is a tool to help the schedule analyst focus on areas that may need further clarification or documentation. For example, although it may be unusual for a healthy schedule to have many tasks with long durations, this is entirely feasible for an IMS that references detailed production activity from an MRP system and uses longer duration tasks to represent the MRP details.

Planner/Schedulers should understand the program goals in regard to schedule health metrics. They should work with program management to construct a metrics package that serves the program's needs. It is important to note that these metrics simply indicate a potential issue that needs either mitigation or justification. The IMS should always represent the program's path forward. Refrain from constructing a schedule that does not represent the program's path forward in order to achieve a favorable schedule health assessment.

The table below (Figure 10.2-1) contains a list of metrics often used to assess schedule health.

Check For	Rationale	Remarks
Tasks Missing Logic (predecessors and successors)	Link discrete tasks to ensure a meaningful calculation of Total Float and projection of accurate forecast dates.	Metric expressed as number of tasks without a predecessor or successor or the percentage of tasks without logic. Tasks with a SS successor or FF predecessor are often included in this list.
Use of Leads (acceleration of a successor activity)	Leads may distort Total Float and the Critical Path. The reason a lead was used should be documented and have proper justification. The critical path may be adversely affected by the misuse of leads.	Metric expressed as number of tasks with leads or percent of tasks with leads. Additionally, metric may be bounded by the size of the lead.
Use of Lags (delay of a successor activity)	During the status process, task owners often overlook updating lag values, which can result in an inaccurate predictive model. The reason a lag was used should be documented and have proper justification.	Metric expressed as number of tasks with lags or the percentage of tasks with lags. Additionally, the metric may be bounded by the size of the lag.
Relationship Types (SS, SF, FS, FF)	The Finish-to-Start (FS) relationship type provides a logical path through the program. A relationship type such as Start-to-Start (SS) or Finish-to-Finish (FF) can cause resource conflicts when the tasks are dependent upon one another while also taking place at the same time. The Start-to-Finish (SF) relationship type is counter-intuitive ("the successor can't finish until the predecessor starts") and should only be used very rarely and with detailed justification.	Metric is often the percentage of each relationship type. Some metrics measure only the percentage of FS relationships.
Hard Constraints (such as Must Finish On and Must Start On)	Using hard constraints prevents logical predecessors driving tasks and therefore prevents the schedule from being logic driven. The critical path and any subsequent analysis may be adversely affected.	Metric is often the percentage of each type of constraint. Some metrics measure the percentage of hard constraints. Some metrics list the number of hard constraints.
High Float (High Slack)	A task with high total float may be a result of inaccurate or missing predecessors and / or successors. If the percentage of tasks with excessive total float is high, the	Metric is often the number or percentage of high float tasks. Numerically define the term "high". Ensure the numerical

Check For	Rationale	Remarks
	network may be unstable and is not being logic driven. Ensure that health metric thresholds are appropriate for the relative length of the program and consistent with oversight requirements.	definition is consistent with the overall length of the program.
Negative Float (Negative Slack)	A task with negative float is potentially driving key program milestones past contractual date requirements.	Measure the number or percentage of tasks with negative float.
High Task Duration	Higher duration tasking may not provide the necessary precision for future measurement of work completed without significant additional effort on the part of the program.	Measure the number or percentage of tasks with high duration. The SOW or CDRL often expresses duration limits to ensure sufficient granularity of the schedule.
Invalid Forecast Dates	A task should have forecast start and forecast finish dates that are in the future relative to Time Now.	Measure the number or percentage of tasks with invalid forecast dates.
Invalid Actual Dates	A task should NOT have actual start or actual finish dates that are in the future relative to Time Now.	Measure the number or percentage of tasks with invalid actual dates.
Resource Loading	Where resource loading is a requirement, all tasks should be resource loaded, other than summary, milestones, Schedule Margin and SVT tasks.	Where resource loading is a requirement, the number or the percentage of non-resource loaded discrete tasks is often measured. Tailor this metric to be consistent with the local resource loading procedures.
Tasks Without Baseline	All tasks should have baseline elements from which the Performance Measurement Baseline (PMB) is established.	Measure the number or percentage of tasks without baseline elements (i.e. dates).
Summary Task Logic	Summary tasks with logic can result in incorrect schedule date calculations or at a minimum, can reduce the precision of the schedule.	Measure the number or percentage of tasks with Summary Task Logic.
Planning Packages Requiring Detail Planning	Planning Packages need to be detail planned before they begin.	Measure the number of planning packages within the freeze period.
Out of Sequence Status	Out-of-Sequence tasks are those tasks where the execution is contrary	Measure the number of Out-of-Sequence tasks.

Check For	Rationale	Remarks
	to the logical relationship of the tasks. Typically, this occurs when an incomplete predecessor is "driving" a started task. This may result in inaccurate successor path forecast dates and Total Float Calculation.	
Over-allocated Resources	Resource loaded schedules have the ability to show over-allocations that may hinder program progress.	Measure the number of tasks with over-allocated resources.
Vertical Schedule Integration Violations	All tasks should flow up to their summary tasks. Errors here limit the use of summary schedule to portray accurate program status.	Measure the percentage of tasks that fail vertical integration checks.

Figure 10.2-1 Table of possible Schedule Health Assessment metrics

Examples

A number of commercial and government owned tools are available to automate schedule health assessments. Shown below are two examples (Figure 10.2-2 and Figure 10.2-3) of the outputs of these tools. These tools often come with Schedule Health Assessment criteria set as a default. The first is an output chart from Steelray Project Analyzer.

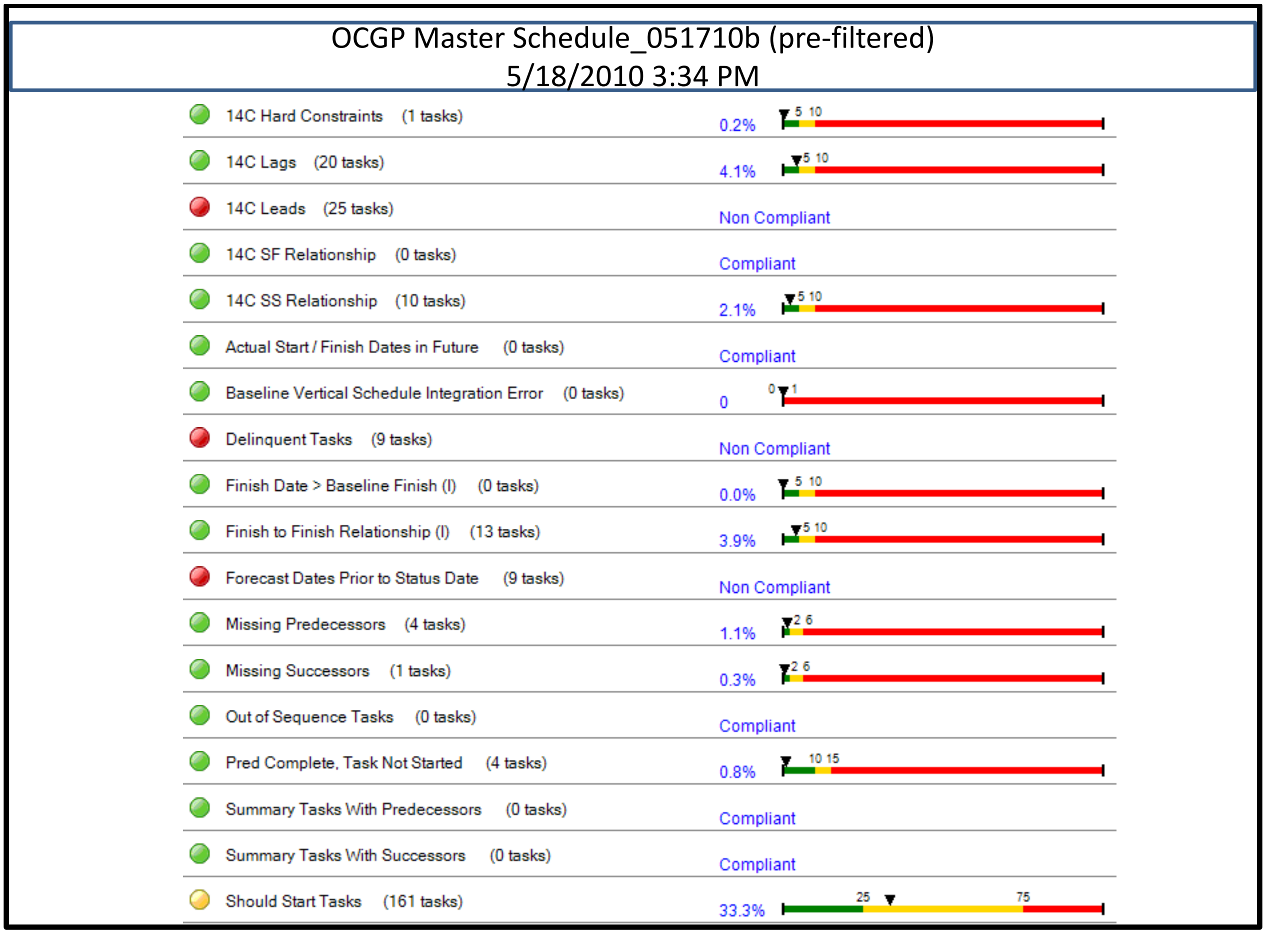


Figure 10.2-2 Steelray Example of Health Assessment Metrics

Caveat on this Figure 10.2-2: This example is included for demonstration purposes only and *does not advocate* the use of one tool over another.

The next example is an output from RunAzTech by AzTech International LLC.

5,997 Total Tasks = 1,391 Summary Task(s) + 4,606 Detailed Task(s) [0 Ext'l Task(s)]						
Statistics:	Detailed	Discrete	LOE	PPkg	Milestones	
Total Tasks	4,606	3,205	-	-	1,401	All Detailed Tasks (excludes Summaries)
Complete	3,152	2,240	-	-	912	Completed Detailed Tasks (have Actual Finish)
Complete %	68%	70%	0%	0%	65%	% Completed Detailed Tasks
Incomplete	1,454	965	-	-	489	Incomplete Detailed Tasks (no Actual Finish)
Incomplete %	32%	30%	0%	0%	35%	% Incomplete Detailed Tasks
In Progress	146	146	-	-	-	In Progress Detailed Tasks (have Actual Start)
In Progress %	10%	15%	0%	0%	0%	% In Progress Detailed Tasks
With Logic	1,055	711	-	-	344	Tasks with Logic (Predecessor & Successor)
With Logic %	73%	74%	0%	0%	70%	% Tasks with Logic
Missg Logic	399	254	-	-	145	Tasks missing a Predecessor or Successor
Missg Logic %	27%	26%	0%	0%	30%	% Tasks missing Predecessor or Successor
No Preds	166	104	-	-	62	Tasks missing a Predecessor
No Preds %	11%	11%	0%	0%	13%	% Tasks missing Predecessor
No Succs	309	203	-	-	106	Tasks missing a Successor
No Succs %	21%	21%	0%	0%	22%	% Tasks missing a Successor
Avg Ttl Flt < 0	-218d	-242d	0d	0d	-35d	Average Negative Total Float
Total Flt < 0	25	22	-	-	3	Tasks with Negative Total Float
Total Flt < 0%	2%	2%	0%	0%	1%	% Tasks with Negative Total Float
Avg Ttl Flt > 0	428d	449d	0d	0d	391d	Average Positive Total Float
Total Flt >= 0 <= 44	356	272	-	-	84	Band 1: Total Float >= 0 & <= 44
Total Flt >= 0 <= 44%	24%	28%	0%	0%	17%	% Tasks for Band 1
Total Flt > 44 <= 120	341	263	-	-	78	Band 2: Total Float > 44 & <= 120
Total Flt > 44 <= 120%	23%	27%	0%	0%	16%	% Tasks for Band 2
Total Flt > 120	732	408	-	-	324	Band 3: Total Float > 120
Total Flt > 120%	50%	42%	0%	0%	66%	% Tasks for Band 3
Avg Duration	41d	61d	0d	0d	0d	Average Task durations
Dur >= 0 <= 44	1,213	724	-	-		Band 1: Duration >=0 & <=44
Dur >= 0 <= 44%	83%	75%	0%	0%		% Tasks for Band 1
Dur > 44 <= 120	102	102	-	-		Band 2: Duration > 44 & <= 120
Dur > 44 <= 120%	7%	11%	0%	0%		% Tasks for Band 2
Dur > 120	139	139	-	-		Band 3: Duration > 120
Dur > 120%	10%	14%	0%	0%		% Tasks for Band 3

Figure 10.2-3 Aztech International example of Schedule Health Assessment.

Caveat on Figure 10.2-3: This example is included for demonstration purposes only and *does not advocate* the use of one tool over another.

Calculations

Schedule Health Assessment metrics should not have defined threshold requirements but rather threshold guidelines that serve as trigger points for additional analysis. In the event a program exceeds a threshold guideline, the actions taken to identify and correct the IMS should be the result of a defined and repeatable process. The importance of metrics and the guidelines or standards may vary by program phase and/or program type. This document does not provide thresholds. Programs should define the exclusions to the calculation of their metrics. Most metrics focus on the remaining efforts of the IMS rather than past performance. Most metrics exclude milestones, summary tasks and LOE, thereby focusing on discrete tasks that have effort associated with them. Additionally, many metrics may exclude Planning Packages.

Most tools use percentage calculations that make comparisons across programs convenient. In cases where one instance of a missed metric is a significant issue, the metric is often the number of tasks that miss the mark.

Optional Techniques

DCMA makes available to the public a set of schedule assessment techniques. These techniques are manual but do not require any additional software costs.

Items identified by the schedule health assessment that are not “fixed” in the IMS model should be justified. One method of maintaining this justification is to include an explanation in the “notes” field in the IMS. It is important to ensure the justification process used by the contractor is included in the IMS Supplemental Guidance document.

Things to Promote

Regular use of a schedule health assessment and trending commentary contained in the "schedule health assessment report" provided to the customer in the IMS Narrative, when required.

Give priority to improving the schedule health. The ability to use the schedule to predict future performance requires a sound schedule.

Ensure the program is addressing IMS health concerns in a logical order of precedence. Address items with the biggest deviation from the established standards first.

Communicate the reason for performing schedule health metrics to all of the task owners, not just to the planner/schedulers.

Ensure that health metric threshold guidelines are appropriate for the relative length of the program and consistent with oversight requirements.

Things to Avoid

Avoid creating an environment driven to eliminate variances to the metrics standards as the primary goal as this objective typically drives bad behavior and will likely result in an erroneous IMS. Do not let the metrics drive the schedule, rather the schedule health should be reflected in the metrics.

Avoid viewing all schedule health metrics as a "pass/fail" mechanism, but rather an analytical tool for discovering areas that may need further focus and/or clarification.

Related Topics

Desktop Procedures
Horizontal Traceability
IMS Supplemental Guidance
Critical and Driving Path Analysis

10.3 Risk and Opportunity

This section contains the following chapters.

10.3.1 Incorporation of Risks and Opportunities

Manager's View

Identifying and addressing Risks and Opportunities (R&O) supports the achievement of cost, schedule, and technical objectives and is part of any Program Management strategy. The integration of the risk mitigation or opportunity capture plans from the R&O database/register directly into the Integrated Master Schedule (IMS) allows progress to be monitored during the normal status cycle. This establishes an efficient forward-looking process that will help program managers make informed decisions faster, leading to improved performance and increased customer confidence.

Description

Process elements such as Organization, Identification, Analysis, Planning, Authorization (implementation), Progress Measurement (tracking) and Revision / Closeout are common to most risk management systems.

A sample process follows.

Risk and Opportunity Management Process	
1. Organization	• Prepare R&O Management Plan • Configure supporting computer • Conduct initial R&O review
2. Identification	• Identify R&O candidates • Initial Assessment
3. Analysis	• Assign project and WBS • Determine likelihood / consequence • Review board acceptance
4. Risk Mitigation / Opportunity Capture Planning	• Identify feasible alternatives • Prepare risk mitigation / opportunity capture plans • Coordinate with stakeholders
5. Work Authorization	• Authorize risk mitigation / opportunity capture plan • Implement action plans (incorporate into the IMS)
6. Progress Measurement	• Gather, assess and record plan status • Report R&O status to Program Management
7. Revision / Closeout	• Reclassify, edit R&O item or action plan • Close R&O item

Figure 10.3.1-1 Risk and Opportunity Management Sample Process

By mapping risk or opportunity activities in the IMS (using standard activity codes available in most scheduling software), the program schedule becomes the single source for R&O plan status resulting in elevated visibility and ensures that the program team addresses risk and opportunities during the regular update cycle.

At a minimum, the individual schedule activities should be traceable to individual risks and opportunities in the R&O database/register. It is possible to include other information that can be used to help automate reporting and accountability such as the expected likelihood and consequence of occurrence, risk owner etc. The day-to-day execution of the program provides the earned value, accounting and schedule metrics needed to manage and understand the probable impact of risks and opportunities. When the status is originated directly from the IMS the possibility for dual entry, conflicting reports and time-consuming reconciliation is eliminated.

Standard work authorization rules apply to any risk mitigation or opportunity capture activities, avoiding questions about properly authorized verses proposed effort. The documented Risk Management Process should describe the methodology that allows the program to identify feasible alternatives, develop Risk Mitigation / Opportunity Capture plans and move them into the approved program schedule when appropriate.

Example

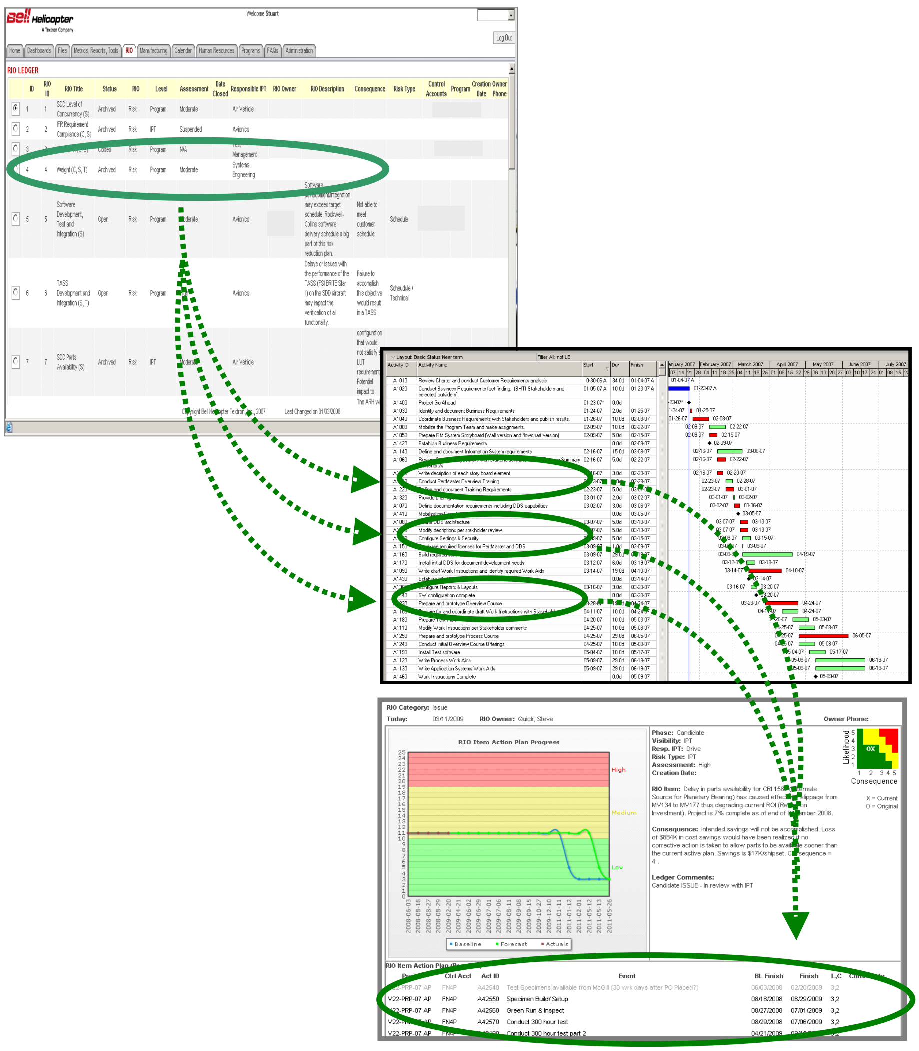


Figure 10.3.1-2 Integrating Risks and Opportunities into the IMS
(Example only; not intended as a standard)

Sample Risk and Opportunity (R&O) Management Process Outline

1-Organization

Prepare a Program Charter that defines the following:

- Program-specific R&O Management requirements and processes
- The schedule for R&O related reviews and recurring meetings
- Program-unique thresholds for ranking and prioritizing R&O Items
- Customer reporting requirements
- Program-unique strategies
- Roles and responsibility for the conduct and coordination of R&O activities that will be performed during execution of the program
- Roles, responsibilities and operating rules for the R&O Management Board (person or group responsible for accepting/rejecting candidates)

2-Identification

- Provide a practical way to bring potential items to the attention of R&O Management Board
- Identify and appoint an Owner for each item
- Assign a unique identification number to each risk and opportunity
- Record each R&O into the Risk database/register or in a controlled tracking document

Risk /Opportunity Listing: Main
9/27/2010
Program(s): ... Project(s): ... R/O ID(s): ... R/O Category(ies): ... R/O Owner(s): ... R/O Level(s): ...

ID	R/O ID	R/O Title	Status	Category	R/O Level	Assessment	Date Closed	Resp. IPT	R/O Owner	R/O Description	Consequence
51	CRI_1478	CRI 1478 - Reduce Part Count for Wing Ribs (Ph1)	Open	Risk	IPT	High		Wing	Mike	CRI 1478 (Reduce Part Count - Wing Ribs): Late implementation may degrade cost savings. The goal of this CRI is to incorporate the rib chords directly into the cap of the shear ties (eliminating 2 parts/rib). This is similar to other wing torque box designs. Additionally, integrating the shear tie fittings into the rib webs eliminates another 2 parts/rib. These changes could eliminate over 1000 hi-lites fasteners per wing.	Consequence of risk realization is a loss of savings to the extent the goal is not achieved. Consequence Level 5 is based on shipset savings of $254.3K.
R/O Type	**Ctrl Accts**	**Program**	**Project**	**Creation Date**	**R/O Owner Phone**	**Comments**					
Cost	VV12	XYZ	MY-CRI-1 AP	3/10/2010	806-341-xxxx						

Figure 10.3.1-3 Entering Risks and Opportunities into a controlled tracking document
(Example only; not intended as a standard)

3-Analysis

- Identify all active Programs/Contracts that are affected by the risk (opportunity)
- Identify all active Control Accounts/Work Packages/Schedule Activities that are affected by the risk or opportunity
- Identify an event, or combination of events, that should occur for a risk or opportunity to be realized
- Identify the contributing factors that influence the extent to which such events will impact planned objectives
- Summarize analysis in terms of a single “Likelihood” rating that will be used to plot the risk or opportunity on a “Risk/Opportunity Matrix”
- Identify the impacts that the realization of a risk or opportunity will have
- Quantify impacts in terms of schedule slips/gains and incremental direct cost dollars
- Express impacts in terms of a single “Consequence” or “Benefit” rating that will be used to plot the risk or opportunity on a “Risk/Opportunity Matrix”
- Submit to the R&O review board for a qualification decision

What do these “Risk/Opportunity Matrices” look like?

Risk Matrix

The DoD standard "Risk Matrix" (Figure 10.3.1-3) used for assigning rankings to a risk. (Note: the customer may define different Risk matrix values and colors.)

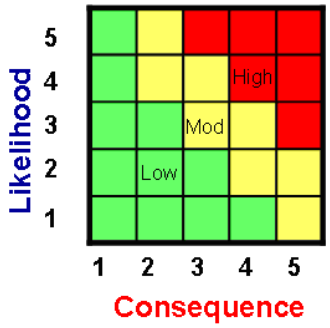


Figure 10.3.1-4 Risk Matrix
(Example: not intended as a standard)

A Likelihood ranking of 5 would be the highest probability of occurrence with 1 being the lowest chance. Assignment of a Consequence rating of 5 would mean that the detrimental impacts, should this risk occur would be severe. Risk rankings in the red area are High Priority; those in the yellow are Moderate Priority; and those in the green are Low Priority.

Opportunity Matrix

While there is no standard method for displaying opportunities (Figure 10.3.1-4), the application of "Olympic colors" (gold, silver, bronze) to the Opportunity Matrix is sometimes used. Since opportunities are the inverse of risks, the consequence scale has been replaced with a benefit scale, and a rating of 5 on the likelihood scale is a "good thing" rather than something to be avoided.

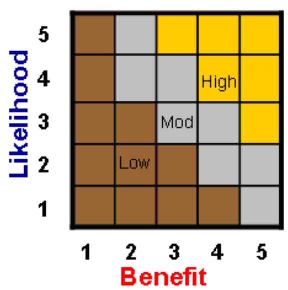


Figure 10.3.1-5 Opportunity Matrix (Example; not intended as a standard)

4- Risk Mitigation / Opportunity Capture Planning

- Identify and select alternative approaches for handling each R&O
- Define the results that are expected to be achieved in the handling of each "Open" item
- Prepare a Risk Mitigation / Opportunity Capture Plan that details the activities (steps)
- Associate expected changes in Likelihood or Consequences that are anticipated to occur as a result of the completion of the mitigation / capture steps
- Estimate scheduled completion dates for each step in the plan
- Estimate the resources required to achieve the desired results

- Enter the steps and resources in the appropriate cost/scheduling tools (i.e. IMS) along with coding necessary for R&O tracking (a unique Risk or Opportunity identification number at a minimum)

5-Work Authorization (Implementation)

- Evaluate the work content of each Risk Mitigation / Opportunity Capture Plan to determine if any, or all, of the proposed implementation steps require the processing and approval of additional work authorization documents (does the action plan represent new scope?)
- Coordinate and initiate the actions needed to generate and release all required work authorization documents including, but not limited to:
    - Contract Modifications
    - Purchase Orders (PO)
    - Baseline Change Requests (BCR)
- Ensure that all costs incurred in the performance of the Risk Mitigation / Opportunity Capture Plans are recorded against valid charge numbers that have been authorized prior to work being performed or resources being expended
- Ensure that all stakeholders and participants in the execution of an Action Plan understand their work assignments and roles in implementing the plan
- Ensure that all Control Account Managers (CAMs) impacted by the Action Plan understand and record, when applicable, the expected effect of the plan on each Control Account's Estimate to Complete (ETC) and Estimate at Completion (EAC)

6-Progress Measurement (Tracking)

- Assess the completion status of the steps in each Action Plan
- Identify changes to "likelihood" and "consequence/benefit" ratings
- Inform stakeholders changes to likelihood and consequences/benefits in a timely manner
- Ensure that changes that could impact downstream performance are communicated
- Identify items that require submission to the Risk Management Board for review

7-Re-classify / Close-Out

- Ensure that all Risk and Opportunity records in the R&O database/register are maintained to ensure items classified properly and described correctly
- Ensure items are reclassified in the system from "Risk" to "Issue" once the Risk is realized
- Consider closing or reclassifying the item when the Risk Mitigation / Opportunity Capture plan is completed

Things to Promote

Automate transfer of data between R&O management tool and the IMS.

- Limits/eliminates redundant effort
- Limits translation errors and reconciling effort

Display R&O information with related management data such as EVMS Dashboards, Labor Accounting, Schedule Metrics and Reports, etc.

- Improves visibility
- Effects on cost/schedule performance, Estimates at Complete (EAC), etc. can easily be compared and analyzed
- Easily automated minimizing unnecessary effort and errors

Assign "ownership" of each risk and/or opportunity so that someone is tracking each item throughout the life of the program.

Provide R&O management training for various roles and responsibilities including but not limited to Control Account Managers (CAMs), Planner/Schedulers, Program Managers, Company Executives, etc.

Ensure R&O management procedures and processes are documented and maintained.

Identify Risk and Opportunities during the IMS creation process and carefully document the associated assumptions and uncertainty.

Use the IMS to facilitate “what-if” analysis to determine the cost, schedule, and technical “return on investment” of activity mitigating a risk or pursuing an opportunity.

Things to Avoid

Avoid losing traceability between the R&O database/register and the IMS.

Avoid conflicting status and vague or overly broad action plans

Related Topics

Baseline Change Management
Vertical Integration and Traceability
Managing using the IMS
Integration of Management Tools

10.3.2 Schedule Risk Assessment (SRA) – Setup and Execution

Manager's View

The probability of overrunning a program schedule can be assessed by determining how much schedule risk exists and where it is greatest. The Schedule Risk Assessment (SRA) enables Program Managers to estimate the time and significance of those risks. This is achieved by identifying the highest risk items along the critical and near critical paths in the schedule. This also involves calibrating the risk thresholds of all activities. At the same time, Program Managers should assess all opportunities and consider their probable impact to the schedule during this analysis. The combination of these factors during an SRA will result in a more accurate vision of the schedule's likely completion. Additionally, through the SRA process, the program team gains an enhanced understanding of the program's risk and opportunity profile. Many SRA SMEs believe that this is the primary benefit of performing an SRA.

The IMS model, including all tasks, logical relationships, durations, constraints and lags should be validated prior to performing a Schedule Risk Assessment.

The frequency of Schedule Risk Assessments should be consistent with the risk and complexity of the program. The contractor may elect to conduct SRA analyses more frequently than required by the contract. The optimum case is for the customer and contractor to discuss and agree on the SRA frequency.

Description

The following table (Figure 10.3.2-1) contains an example of the steps taken during a Schedule Risk Assessment.

Preparation	**1. Establish Expectations**	Establish and agree to the ground rules and assumptions
	2. Determine Reporting Tasks	Determine the key or high-risk tasks/milestones for which statistical data will be collected during the risk analysis (simulation)
	3. Assess and Prepare IMS	Ensure the IMS is healthy and consistent with the ground rules and assumptions
Data Collection	**4. Determine Critical/Driving Paths and High-Risk Items**	Identify and validate critical, near critical, driving, and near driving paths, in addition to the high-risk tasks which will require individual three-point estimates
	5. Determine Three Point Estimates	Solicit and validate CAM inputs for individually determined and globally applied (for tasks that are not high risk or on a critical/driving path) three-point estimates
	6. Determine Distribution Curves	Solicit and validate CAM inputs for distribution curves based on known factors about tasks, three-point estimates, and confidence in the schedule

Execute	**7. Conduct Risk Analysis**	Setup the SRA files, assign risk parameters, run the risk simulation and analyze the results
Results	**8. Produce SRA Out Brief**	Develop and provide an SRA out brief to leadership
	9. Leadership Follow-up	Determine follow-up actions to reduce or eliminate risks and/or capture opportunities. Monitor execution and SRA trends over time.

Figure 10.3.2-1 Example Schedule Risk Assessment (SRA) Process Flow

Technical Details

The Schedule Risk Assessment determines program-level schedule risk as a function of risk associated with various activities that compose the program. Probability distributions are developed for each activity using 3-point duration estimates (Maximum, Most Likely, and Minimum) with reference to historical data. The method uses these distributions in a Monte Carlo simulation of the schedule to derive a probability distribution of total program completion or other key dates within the program. It also identifies the activities most likely to delay the program completion so they can be targeted for risk mitigation. The resulting program level schedule is then analyzed to determine the actual schedule risk and to identify the schedule drivers.

Schedule Risk Assessment expands the Critical Path Method (CPM) of determining the most likely finish dates by considering the probability and impact of risks and opportunities on the Integrated Master Schedule. The CPM approach uses only a single point (most likely) estimate for the duration of program activities to develop the programs expected duration and schedule.

Use of only a deterministic schedule management approach can lead to underestimating the time required to complete the program and schedule overruns. This occurs for three reasons:

- The single point estimates do not adequately address the uncertainty inherent in individual activities and in many programs are underestimated
- Predicting the future is difficult and humans tend to be optimistic about it
- The structure of the schedules implies extra risk at points where paths merge

At these merge points a delay on any of the merging paths will cause the program to be delayed, so its progress is sensitive to delays on all paths. After the SRA is run the Risk software will indicate how often a task is on the critical path for the number of trials. Tasks on the Critical Path a high percentage of the time represent the “Probabilistic Critical Path” and may be different from the “Deterministic Critical Path”

Schedule Risk Assessment Parameters

- 3-point Duration Estimates – developed using consistent criteria with accompanying rationale
    - Individually assigned 3-point durations = tasks on critical and near critical paths
    - Individually assigned 3-point durations = tasks driving key program level milestones (SRR, PDR, CDR) which are of interest to the Program Team
    - Individually assigned 3-point durations = tasks tied to risk mitigation or capture opportunities as called out in the program’s Risk and Opportunity Management Process

- Globally assigned 3-point durations = logical groupings of tasks that are not individually assigned

- Distribution curves
  - There are a multitude of distributions curves available for programs to use during SRA. Please ensure you understand the available options and the rationale for their use. The following three distribution curves are the most common.
    - **Beta Distribution**
      - *Use when:* you have a high confidence in 3-point durations
      - *Curve is:* bell shaped and falls very quickly from the peak
      - *Peak is:* off center
    - **Normal Distribution**
      - *Use when:* you have a moderate confidence in 3-point durations
      - *Curve is:* bell shaped and falls quickly from the peak
      - *Peak is:* center
    - **Triangular Distribution**
      - *Use when:* risk is high, historically realized or unknown or on globally applied 3-point durations
      - *Curve is:* triangular shaped distribution curve that steadily decreases
      - *Peak is:* off center
    - **Uniform Distribution**
      - *Use when*: limited information is known about the potential impacts of the risk to the program.
      - *Curve is:* uniformly shaped
      - *Peak is:* no peak

Things to Consider

Performing an SRA requires the use of a tool that integrates the elements required for running the assessment (such as the 3 point estimate, task uncertainty, scores for risk probability and impact, risk priority rating, etc.), performs a Monte Carlo simulation, displays the probability histogram, and creates output reports.

Hard Constraints – remove hard constraints from the IMS prior to running an SRA as hard constraints impact the forward and backward pass and can cause inaccurate SRA results

Level of Effort (LOE) – an LOE task should never drive discrete work. It should be excluded from the SRA.

Planning Packages – for SRA purposes treat Planning Packages the same as every other discrete task by ensuring they are logically linked in the network and have 3-point durations assigned.

Interface Hand-off Milestones – these represent receipts/deliveries from/to external sources and will need modification to accurately impact the SRA process. Methods for consideration include using 3-point milestone date estimates (not all risk tools can do this), or assigning the earliest receipt/delivery dates as a soft start constraint then adjusting the most likely duration to be consistent with the most likely receipt/delivery date and the worst case duration to be consistent with the worst case receipt/delivery date (this might require duplicating the milestone as a task in some tools).

Note: when modeling 3-point estimates on milestones ensure that the succeeding relationships are all FS.

See Schedule Risk Assessment in DI-MGMT-81650 (IMS DID) or Integrated Program Management Report (IPMR) DID 81861A for additional information and requirements.

Calculations

Monte Carlo simulation is the most common technique used when performing an SRA. The Monte Carlo method is a set of computational algorithms that rely on repeated sampling to compute their results. This method is most often used when it is unfeasible or impossible to compute an exact result with a deterministic algorithm. Various combinations of each input variable are randomly chosen (Min, Max, or Most Likely) based on the distribution curves and the results recorded for each scenario. Monte Carlo simulation considers random sampling of probability distribution functions as model inputs to produce thousands of possible outcomes instead of a few discrete scenarios. The results provide probabilities of different outcomes occurring. The opposite of Monte Carlo simulation might be considered deterministic modeling using single-point estimates.

Optional Techniques

PERT (Project Evaluation and Review Technique) Method

Analyzes the tasks involved in completing a task or milestone within the period of performance of a program. It helps identify the minimum amount of time it will take to complete specific tasks in the program and to complete the entire program.

- *Optimistic time (O):* the minimum possible time required to accomplish a task, assuming everything proceeds better than is normally expected.
- *Pessimistic time (P):* the maximum time required to accomplish a task, assuming everything goes wrong (but excluding major catastrophes).
- *Most likely time (M):* the likeliest estimate of the time required to accomplish a task, assuming everything proceeds as normal.
- *Expected time (TE):* the likeliest estimate of the time required to accomplish a task, assuming everything proceeds as normal (the implication being that the expected time is the average time the task would require if the task were repeated on a number of occasions over an extended period of time).

$$T_E = (O + 4M + P) \div 6$$

(Key: O = Optimistic or Min, M = Most Likely, P = Pessimistic or Max)

Latin Hypercube Sampling

An alternative to Monte Carlo sampling is Latin hypercube. The statistical method of Latin hypercube sampling (LHS) was developed to generate a distribution of plausible collections of parameter values from a multidimensional distribution. The sampling method is often applied in uncertainty analysis. Latin hypercube is often used where the sample size is small.

Things to Promote

A well-constructed IMS with a sound logical network is essential to conducting a good SRA.

Program Management (as well as government program management) support and commitment to the process will yield more realistic and actionable results.

Commitment to the SRA process will give the program insight to previously unseen risks and opportunities that could affect the schedule.

Exclude LOE and recurring CDRL deliveries from the SRA analysis.

If a Schedule Margin task is used in the IMS, its durations should be zeroed out prior to running an SRA such that the Schedule Margin task does not impact the probability calculations of the discrete tasking in the IMS

Document the methodology for determination of minimum and maximum duration estimates in the IMS Supplemental Guidance and if applicable the Risk Management Plan.

Things to Avoid

The file used to conduct the SRA should never be reused as the working file. The algorithms used during the Monte Carlo analysis could affect the data in other fields.

Base the SRA on the program's logical network that represents the true path forward. Avoid making changes to the logic network that do not represent that true path forward during the SRA process.

Related Topics

Critical and Driving Path Analysis
Incorporation of Risk and Opportunities
Task Duration

10.3.3 Schedule Risk Assessment (SRA) – Analysis

Manager's View

Conducting SRAs will lead to the development of more realistic program schedules and help managers make timely, informed decisions that increase the probability of achieving or exceeding expectations. Based on the output analysis, an SRA may also lead to opportunities to develop and implement risk mitigation plans.

Risk Histograms

- Identify the probability of "on time" program completion
- Displays the confidence levels for specific events to occur on specific dates

Sensitivity Analysis and Criticality Indexes

- Isolate specific activities that are most likely to:
  - Cause a schedule delay or cost overrun
  - Provide opportunity to bring in schedule or decrease cost

The payoff is a forward-looking process that will help program leaders make informed decisions faster, leading to improved performance and increased customer confidence.

Description

Probability Thresholds – Prior to conducting an SRA, programs define the probability thresholds and understand what actions could result from an SRA output. The probability threshold is the completion probability of success for any milestone (i.e. the program may accept an 85% probability of completing the program by the contractually required date). This threshold is completely dependent on the program and customer specificities. The program should determine its threshold objectives and socialize these objectives with all stakeholders.

Output Analysis – The data that comes out of the schedule risk assessment is for analysis purposes. This data allows for the identification of risks and opportunities within the program IMS. No one output should be used in isolation. When the results are all used in concert, the decisions that are made will be comprehensive, and will make an impact in the right portion of the schedule.

Programs should assess the confidence level and validity of the SRA, communicate results, and propose options to key stakeholders. Clearly identify the items that are eligible and in need of risk mitigation or have an opportunity to implement. Identify the correct stakeholders to create and execute the mitigation plan and then apply the plan to the IMS. Incorporate the results of the analysis into the EAC and IMS forecasts.

If the Completion Probability desired by the program is not achieved as part of the SRA trial, the program team should investigate additional mitigation of the IMS, re-assess the validity of SRA assumptions for Min/Max duration and review the setup criteria (LOE and Milestone Exclusion) to ensure that a valid SRA trial was executed. The goal of running an SRA is in developing a plan which meets the program's Probability threshold.

SRA results should not be perceived as a deterministic predictor of exact dates, but instead a method to understand opportunities/risks that may impact Program milestones. SRA resulting dates represent a hypothetical version of the schedule after risk/opportunity is introduced and before opportunity is acted upon or risk mitigated.

Examples

Sensitivity Analysis (Tornado Chart)

Sensitivity Analysis (Figure10.3.3-1): identifies the tasks, in descending order, that have the largest impact (positive or negative), according to the SRA simulation, on the event.

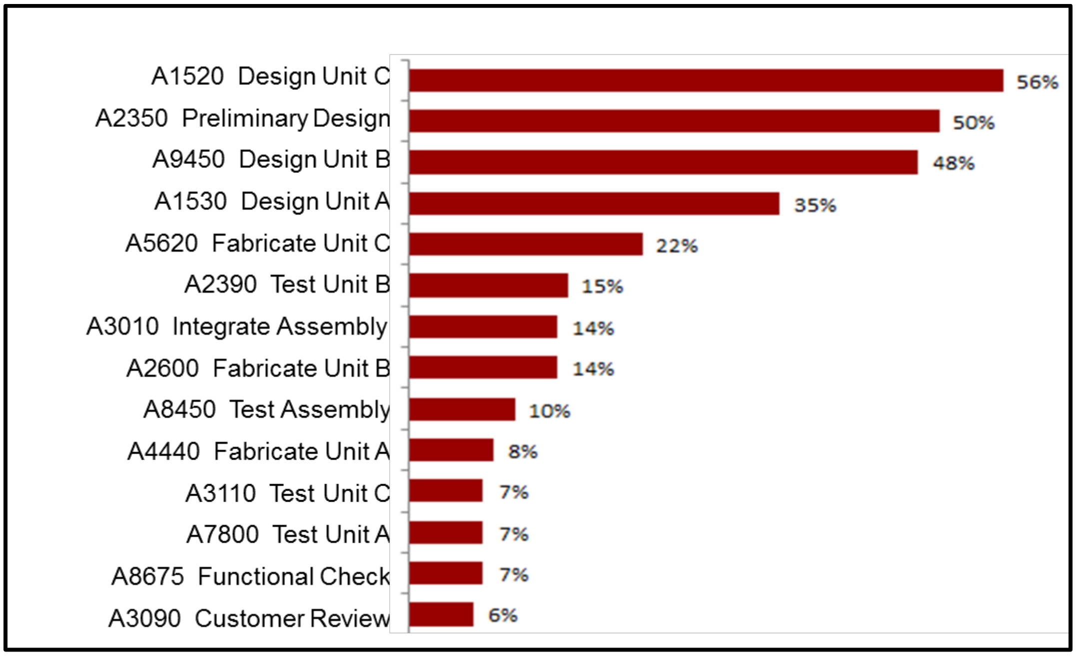


Figure 10.3.3-1 Sensitivity Analysis, also known as a tornado chart

Analysis Histogram

Analysis Histogram (Figure 10.3.3-2): calculates the probability of completing the selected event per the current forecast (or any other desired date).

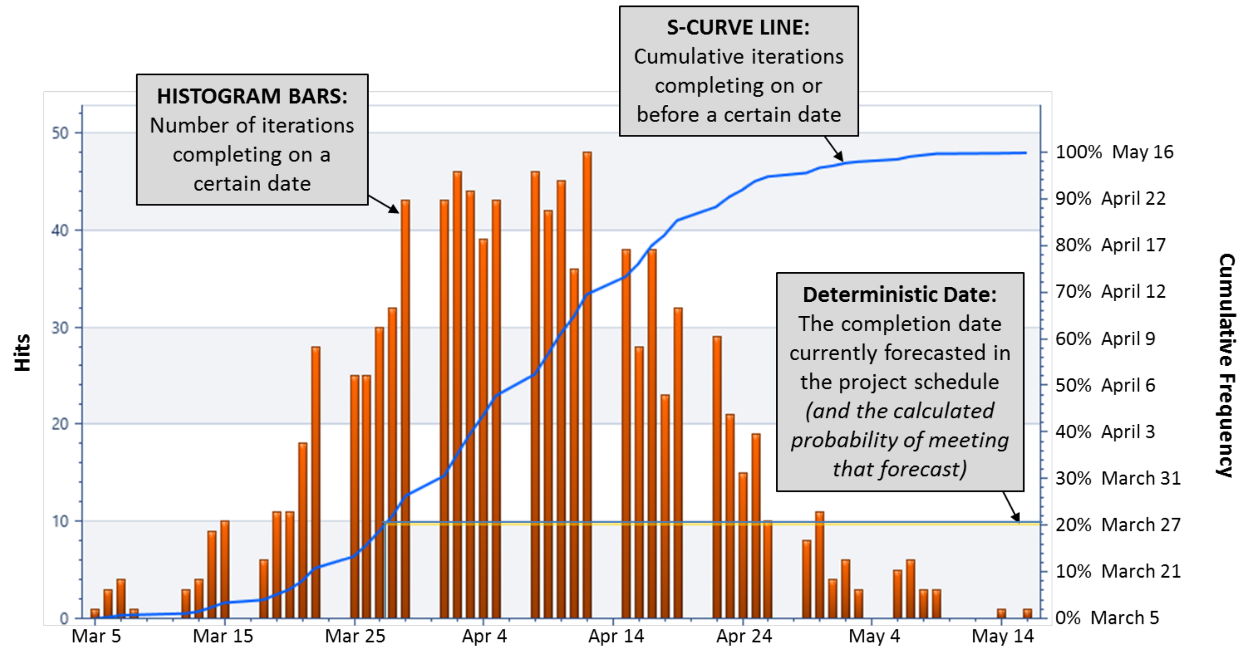


Figure 10.3.3-2 Risk Histogram Sample output

Criticality Index

Criticality Index (Figure10.3.3-3): expresses how often a particular task was on the Critical Path during the analysis

Task Name	Criticality Index
Complete HW & SW Final Integration	75%
Conduct Final Integration Check-Out	70%
Perform Final System Verification	60%
Write Final Check-Out Test Plan	30%
Write Final Check-Out Test Procedures	20%
Assess & Resolve Final Test Results	15%

Figure 10-3.3-3 Criticality Index Example

Calculations

Mean – this is the standard average of all simulated durations on the task. For non-normal distributions (triangular and beta) the mean may differ from the median and mode.

Median – the value separating the higher 50% from the lower 50% of the probability distribution.

Mode – the value that occurs most frequently in the probability distribution.

Standard Deviation – shows how much variation exists from the average or mean. A low standard deviation indicates that the data points tend to be very close to the mean and a high standard deviation indicates that the data is spread over a large range of values. It is also an indirect indicator to the relative average duration of tasks in the IMS. A critical path consisting of 10 tasks, each 2 days long will have a much lower Standard Deviation than a Critical Path consisting of 5 tasks, each 4 days long, even though the Critical Path length is the same.

Criticality Index – The Criticality Index of a task is expressed as a percentage. During a simulation, (e.g. Monte Carlo) tasks can join or leave the critical path for any given iteration. The Criticality Index expresses how often a task was on the Critical Path during the analysis.

Tasks with a high Criticality Index are more likely to cause delay to the program, as they are more likely to be on the Critical Path. Although, the tasks that show up as having a high criticality index may not have inherent risk.

Analysis of the Criticality Index, those tasks which enter the Critical Path at some time during the SRA analysis, are tasks that should be examined for mitigation to reduce duration and achieve the most rapid improvement in improving the probability of success.

Sensitivity Analysis – The sensitivity analysis is a technique for systematically changing parameters (i.e., a duration) in a model to determine the effects of such changes. This process will yield a “tornado” chart and will identify the tasks, in descending order, that have the largest impact (positive or negative) on the event they lead up to and will benefit most from action taken against them.

The Sensitivity Analysis results should also help in identifying tasks for which mitigation would most effectively benefit the program. These tasks are typically on the Critical or Near Critical Path(s). The most effective method of achieving reduced program duration is to examine the Critical Path with the secondary and tertiary Critical Paths, code these IMS tasks so they can be displayed together and identify the intersection points of these various paths as points to mitigate. Mitigating this one intersecting task, or an IMS task immediately succeeding it, has the effect of mitigating both branches at the same time. Work your way down the path, identifying areas that mitigation can be applied to achieve duration reductions that bring the analysis to the program’s acceptable probability of success.

Confidence Interval – The size of the interval that contains the real mean to the specified level of certainty.

Completion Standard Deviation – For distributions that approximate the normal curve, this reflects that about 68% of the completion dates should be within plus or minus the number of days specified.

Completion Probability – This is the probability of completing the reporting task by a certain date. The Completion Probability date has a plus/minus range of days indicated in the standard deviation.

Things to Promote

Any schedule improvements supporting the SRA process should be considered and possibly implemented in accordance with the organization’s documented Baseline Change Management process.

Ensure that new risks and opportunities identified in the SRA process are captured and added to the program’s Risk and Opportunity Register/database.

Related Topics

Schedule Risk Assessment (SRA) – Setup and Execution
Managing using the IMS
Horizontal Traceability
Task Duration

10.4 Schedule Execution Metrics

This section contains the following chapters.

10.4.1 Intro to Schedule Execution Metrics

The following chapters introduce a set of schedule analysis and execution metrics intended to assist the program team in using the IMS to make sound programmatic decisions. The content includes a brief over view of Critical Path Length Index (CPLI), Baseline Execution Index (BEI), and Schedule Performance Index (SPI), Duration-Based v. Scope-Based Percent Complete, Schedule Rate Charts, Total Float Consumption Index (TFCI), and Current Execution Index (CEI). Consider this list of execution metrics as a representative example and not an exhaustive list of schedule execution metrics available to programs. Program teams should develop and tailor a suite of schedule execution metrics in conjunction with other forms of schedule analysis (Critical/Driving Path Analysis, Schedule Risk Assessment, and Schedule Health Assessment etc.) and use them on a recurring basis to interpret and understand schedule health and performance.

Overall, this guide advocates the use of the IMS primarily as a management tool versus a reporting tool. A handful of the schedule metrics listed in this guide may be required for delivery to your internal or external management teams and customers. A word of caution on the value of metrics, avoid manipulating the schedule with the intent of producing favorable metrics for reporting purposes as this severely impacts the value of the IMS as a management tool. It also important to note that frequent baseline changes (i.e. replanning, reprogramming) can also alter the effectiveness of the IMS as a management tool.

Each of the schedule execution metrics presented in the guide, and those that are not in the guide, assess schedule performance in different ways, from various angles and data sets. As such, programs run the risk of drawing false conclusions from a single metric. To mitigate this risk, programs should utilize a suite of complimentary schedule metrics to corroborate potential schedule risks and execution concerns.

Bottom line, the objective of using schedule execution metrics is to identify potential issues, propose and implement solutions, and assess the effectiveness of those solutions. The objective is not to simply have a report card.

10.4.2 Critical Path Length Index (CPLI)

Manager's View

The Critical Path Length Index (CPLI) measures how realistic the program completion date is, based on the remaining duration of the critical path and the amount of total float available. CPLI is one of the standard Schedule Health Assessment Metrics and identifies programs that are having difficulty executing their critical path. The target for CPLI is 1.0 or greater. A lower value indicates an increased risk of being late at program completion.

Description

Calculate CPLI using the following formula:

$$\boldsymbol{CPLI} = \frac{\boldsymbol{Critical\ Path\ Length + Total\ Float}}{\boldsymbol{Critical\ Path\ Length}}$$

Where Critical Path Length is the number of days from time now to the early finish date of the task or milestone representing program completion. Total Float on the task or milestone representing program completion may be either positive or negative.

The result is an index that measures the sufficiency of the total float available relative to the remaining duration of the critical path. For example, 20 days of float on a critical path that has 80 days remaining would result in a CPLI of 1.25 indicating a low risk of not completing on time. However, if the critical path has 800 days remaining, a total float of 20 days would result in a CPLI of 1.03. Although this is still above the target of 1.0, it indicates there is much less room for error. To achieve a CPLI of 1.25 in this case would require 200 days of total float.

CPLI also measures the relative efficiency required to complete the program critical path on time. A CPLI of 1.00 means the program has 0 days of total float available on the critical path and therefore should accomplish one day's worth of work for every day that passes. This means the program should execute the critical path at a 100% efficiency rate to complete on time.

A CPLI less than 1.00 indicates that the program is not executing the critical path as planned and has created a negative total float condition potentially delaying program completion. To prevent this from happening, the program should now accomplish more than one day of work for every day that passes. This means the program should now execute the critical path at an efficiency rate higher than 100%.

Likewise, a CPLI greater than 1.00 indicates that the program is executing the critical path ahead of plan and still has positive total float remaining. As a result, the program has a lower risk of delaying program completion since they can operate at an efficiency rate of less than 100% and still complete on time

Typically, programs calculate CPLI to program completion or an interim milestone. Any activities on or near the program critical path can directly impact this metric if not completed as planned.

Note: CPLI will not work correctly, if the network does not have a constrained finish date on the task representing program completion, because the result would be a Critical Path that has zero total float and a CPLI of 1.00 at all times.

Example

The critical path to program completion is 200 days, measured from the status date (time now) to the early finish date of the program completion milestone. In addition, the total float for the critical path is 20 days. As a result, the CPLI for the program is (200 + 20) / 200 = 1.10. Since the CPLI is above the target of 1.0 it indicates that the program is executing the critical path as planned and only needs to achieve an efficiency rate of 90% going forward to complete on time.

If after three months the total float remains at 20 days, the CPLI would increase to (140 + 20) / 140 = 1.14. Because the program has completed 60 days of work without using any of the total float available, they have increased the likelihood that they will complete on time and now only need to execute the critical path at an efficiency rate of 86% going forward.

However, if after 3 months the remaining duration on the critical path is 160 days with a total float of negative 15 days, the CPLI will decrease to (160 + -15) / 160 = 0.90. This indicates program completion will be late devoid of corrective action. The program would now need to complete 1.10 days of work for every day that passes to complete on time.

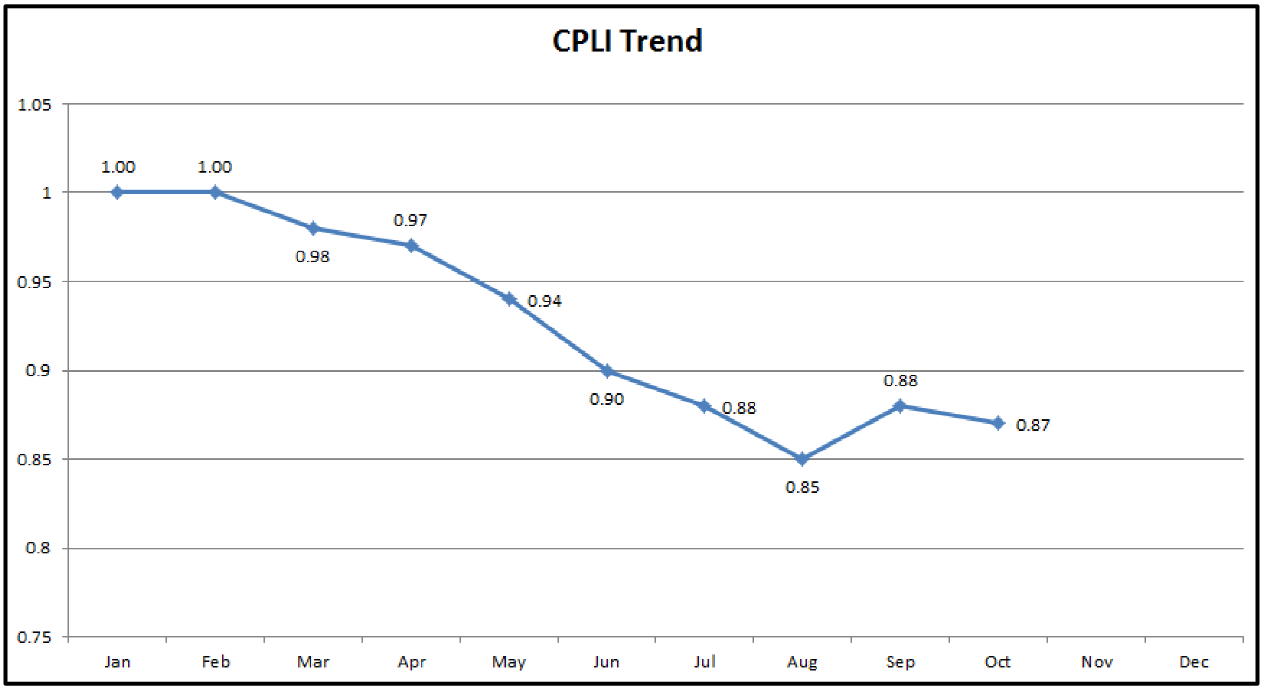


Figure10.4.2-1 Sample Program CPLI Metric, showing trend data for the CPLI calculation

Calculations

$$CPLI = \frac{Critical\ Path\ Length + Total\ Float}{Critical\ Path\ Length}$$

Where Critical Path Length is the number of days from time now to the early finish date of the task representing program completion. Total Float may be either positive or negative.

Resulting Values

CPLI Value	Implication
> 1.00	**Favorable** – The Critical Path is ahead of a plan; Total Float is positive and program completion can still be achieved with an efficiency rate less than 100% going forward.

CPLI Value	Implication
= 1.00	**On Target** – The Critical Path is on plan; Total Float is zero and an efficiency rate of 100% is required going forward.
< 1.00	**Unfavorable** – The Critical Path is behind plan, Total Float is negative, and an efficiency rate greater than 100% is required going forward to recover.

Figure10.4.2-2 Interpretation of CPLI Results

Optional Techniques

The traditional method of monitoring Total Float also provides management with insight into how well the program is executing the Critical Path and provides an early warning of potential impacts to program completion.

Things to Promote

Tracking CPLI results over time to monitor trends can provide additional insight and an early warning into potential problem areas.

Because CPLI is an index, it normalizes the results and allows for comparisons between programs.

Things to Avoid

CPLI is an indicator of the efficiency related to the tasks on the critical path and does not necessarily provide insight into other tasks in the schedule. It is important to monitor other metrics like BEI and SPI and not rely on CPLI as the sole indicator of program schedule performance.

The CPLI metric becomes meaningless once the program has passed its required completion date but is not yet complete.

The CPLI metric will only be accurate if the IMS is a well-constructed predictive model with a validated Critical Path.

Related Topics

Baseline Execution Index (BEI)
Schedule Performance Index (SPI)
Critical and Driving Path Analysis
Current Execution Index (CEI)

10.4.3 Schedule Performance Index (SPI)

Manager's View

Schedule Performance Index (SPI) is an Earned Value Management tool comparing Baseline Cost of Work Performed (BCWP) with Baseline Cost of Work Scheduled (BCWS) to indicate cumulative and monthly schedule performance. It is an early warning tool used to determine if the schedule is at risk and indicates whether the program should increase efficiency to complete on time.

Description

SPI is a summary level snapshot measuring how well the program (or a portion of the program) has actually performed to the baseline plan. SPI is similar in function to the Baseline Execution Index (BEI), except it is a ratio based on the earned value fundamentals of Budgeted Cost of Work Scheduled (BCWS) and Budgeted cost of Work Performed (BCWP).

Comparison to BEI

SPI is similar in function to the Baseline execution Index (BEI). For additional information, please refer to the topics listed below within the BEI chapter:

- Advantages of BEI Over SPI
- Advantages of SPI Over BEI
- End-of-Project Dampening
- "Average" Metric

Example

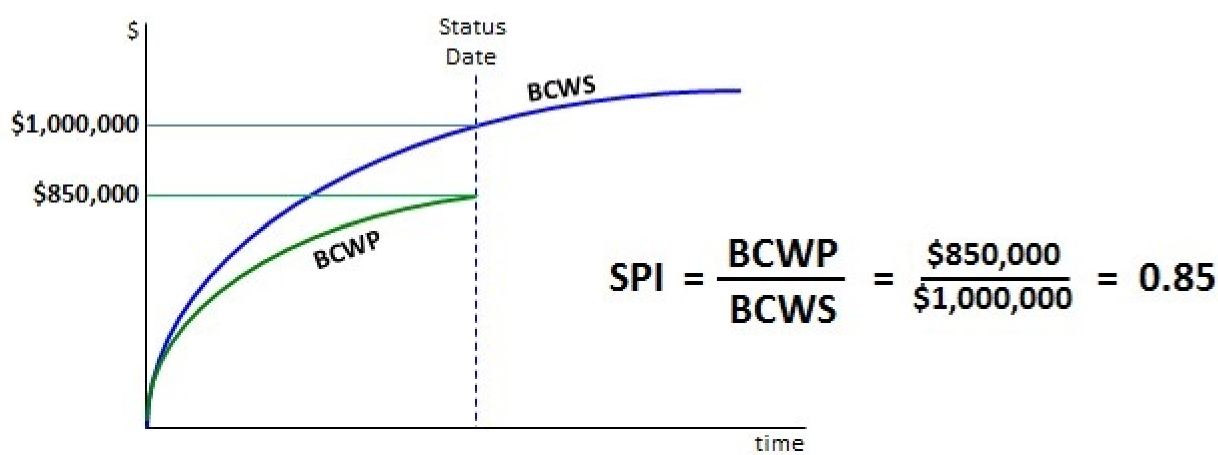


Figure 10.4.3-1 Method of calculation for SPI

Calculations

$$SPI = \frac{BCWP}{BCWS}$$

BCWS (Budgeted Cost of Work Scheduled) – The approved budget allocated to complete a program to Time Now (also referred to as the "Planned Value (PV)").

BCWP (Budgeted Cost of Work Performed) – The budgeted cost of work performed on a program to date (also referred to as the "Earned Value (EV)").

Resulting Values

Similar to BEI or CPI, an SPI value of 1.00 indicates the effort is progressing as planned (per the baseline). Values above 1.00 denote performance better than planned, while values below 1.00 suggest poorer performance than planned.

SPI Value	Implication
> 1.00	**Favorable** – The program on average is being accomplished at a faster than planned rate
= 1.00	**On Track** – The program on average is performing to plan
< 1.00	**Unfavorable** – The program on average is being accomplished at a slower rate than was planned

Figure 10.4.3-2 SPI Interpretation Guide

Periodicity

SPI should be calculated and analyzed after each Earned Value status period. For most programs, this is monthly, but may be more or less frequent depending on the effort or contractual requirement.

Things to Promote

Understanding the impact of LOE, this can skew SPI as it always earns BCWP in-line with BCWS.

BEI and SPI should be used in conjunction with sound critical path analysis, and never as a stand-alone indicator of the health of a program.

Related Topics

Baseline Execution Index (BEI)
Critical and Driving Path Analysis

10.4.4 Baseline Execution Index (BEI)

Manager's View

Baseline Execution Index (BEI) measures the number of tasks completed as a ratio to those tasks that should have completed to date according to the original (baseline) plan. It reveals the "execution pace" for a program and provides an early warning of increased risk to on-time completion.

Note: BEI is one of the standard Schedule Health Assessment Metrics

Description

BEI is a summary level snapshot measuring how well the program (or a portion of the program) has actually performed to the baseline plan. The BEI is a simple index measure of a count of completed tasks with a count of tasks scheduled to be completed. As with most indices, 1.0 is ideal, a number greater than 1.0 indicates more task completions than planned and a number less than 1.0 indicates fewer completed tasks than planned. Management can use this metric to evaluate schedule progress towards the baseline plan. BEI is similar in function to the Schedule Performance Index (SPI), except it is a ratio based on a simple task count.

Advantages of BEI over SPI

Objectivity

- BEI is a more objective metric than SPI
    - Programs consider BEI an objective assessment since it is based on the planned and actual completion of activities.
    - SPI has at least some degree of embedded subjectivity due to the earned value assessments made on in-progress effort.

Potency

- SPI may be a more "watered down" index than BEI
    - Level-of-Effort (LOE) tasks are excluded from BEI calculations. The primary reason for this exclusion is to keep the LOE from "masking" the true state of the program.
    - LOE is generally included in the calculation of a program's SPI (although programs can exclude LOE). Much like BEI, the inclusion of LOE on SPI effectively dampens (skews toward 1.00) the true execution performance of a program.

Advantages of SPI over BEI

- SPI is more sensitive than BEI
    - BEI places equal importance/weight on all activities. Because of this, completing a complex 500-hour activity will affect the metric calculation the same as completing a routine 5-hour activity.
    - SPI weights activities by their planned resource loading. Therefore, activities that require more effort will have a greater affect the SPI calculation.

BEI (and SPI) Flaws

End-of-Project Dampening

No matter how early or late a program completes, BEI (and SPI) calculations will eventually equal 1.00. This is due to the fact that once everything is in the rear-view mirror, the numerator and denominator for BEI will be equivalent (if 1000 tasks were planned to complete and the program is finished, by definition, 1000 activities were actually completed).

While the effectiveness of BEI may vary from program to program, once a program is more than about 85% complete, BEI is generally not considered to be a very accurate (and thus useful) measure of a program's performance.

"Average" Metric

Perhaps the most significant drawback to BEI (and SPI) is that programs base its calculation on the average performance of all tasks. Most programs will have certain areas that are performing better or worse than other areas. BEI combines these areas of mixed performance into a single index. Because of this, programs could make a misleading view of the program by looking at BEI alone. For example, a program might have a BEI of 1.07, but if the activities on or near the critical path are running behind, the program is in danger of finishing late (even though BEI indicates favorable performance).

Examples

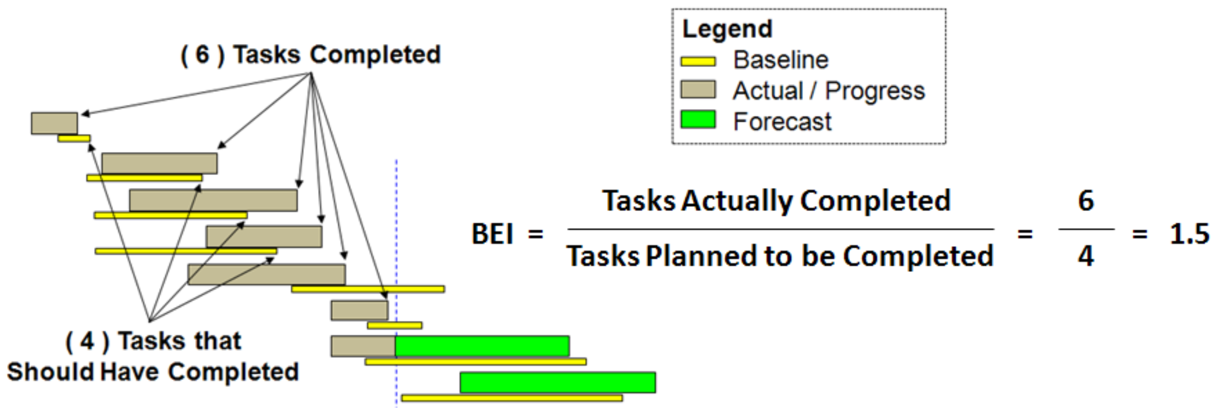


Figure 10.4.4-1 Method of Calculation for the BEI Metric - Gantt Chart Example

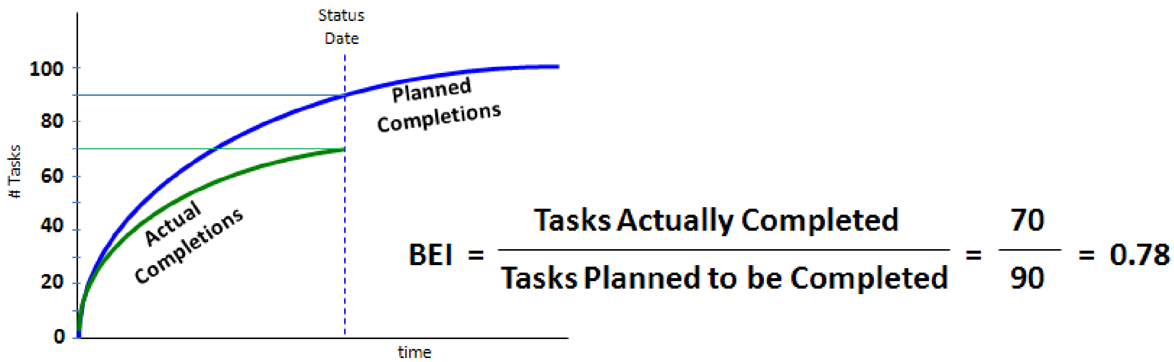


Figure 10.4.4-2 Method of Calculation for the BEI Metric - Schedule Rate Chart Example

Calculations

Formula:

$$BEI = \frac{\#\,Tasks\ Actually\ Completed}{\#\,Tasks\ Planned\ to\ be\ Completed}$$

Tasks Actually Completed - Count of activities with a status updates for Actual Finish dates on or before the status date of the IMS

Tasks Planned to be Completed - Count of activities with a Baseline Finish date on or before the status date of the IMS

Note: While there may be exceptions under certain circumstances, programs typically exclude the following activity categories from BEI counts and calculations: Level of Effort (LOE) and Milestones.

Periodicity

Programs can calculate BEI as often as the schedule has its status updated (typically weekly or monthly).

Resulting Values

Similar to SPI or CPI, a BEI value of 1.00 indicated the effort is progressing consistent with the baseline completion rate. Values above 1.00 denote performance better than the planned baseline completion rate, while values below 1.00 suggest poorer performance than the planned baseline completion rate (Figure 10.4.4.-3).

BEI Value	Implication
> 1.00	**Favorable** – The program on average is being accomplished at a faster than planned baseline task completion rate
= 1.00	**On Track** – The program on average is performing to the planned baseline task completion rate
< 1.00	**Unfavorable** – The program on average is completing tasks at a slower rate than the baseline completion rate.

Figure 10.4.4-3 BEI Interpretative Guide

Things to Promote

Programs can filter down BEI analysis to specific IMS sections (i.e. Control Account, WBS, OBS, Event, or IPT) to facilitate refined analysis. This will allow for a BEI metric to be assessed at any level in your IMS and Program Management can hold Integrated Product Team leads and or Control Account Managers accountable for their BEI metric.

Ensure you understand the implication of historical baseline changes on BEI.

Things to Avoid

BEI and SPI should be used in conjunction with sound critical path analysis, and never as a stand-alone indicator of the health of a program

Related Topics

Schedule Performance Index (SPI)
Critical and Driving Path Analysis
Current Execution Index (CEI)
Schedule Rate Chart

10.4.5 Current Execution Index (CEI)

Manager's View

Current Execution Index (CEI) is a schedule execution metric that measures how accurately the program is forecasting and executing to its forecast from one period to the next. Its design is to encourage a forward-looking perspective to IMS and program management. The real benefit of implementing CEI is an increased program emphasis on ensuring the accuracy of the forecast schedule. This results in a more accurate predictive model and increases the program's ability to meet its contractual obligations on schedule.

Description

The goal of this metric is to measure and indicate how well the near-term schedule represents what actually takes place through execution. This measurement provides insight into the accuracy of the forecast schedule and its abilities as a predictive model. The index maximum is 1.00, but a sound forecast schedule will consistently trend in the greater than 80th percentile range. There is a direct correlation between the lower probability (less than 80 % probability of completion) and the program's ability to manage the projected near-term tasks. This indicates that work is slipping to the right and possibly adding to the "bow wave" of unachievable work. Use of the CEI metric drives ownership and accountability behaviors that are necessary for program success when consistently used by program management.

You can derive CEI by comparing the number of tasks forecasted to finish within the status period to the number of those tasks that actually did finish within the status period.

The process for collecting the data necessary to calculate CEI is as follows:

1. At the beginning of the status period, create a "snapshot" of the status period (capturing Forecast Finishes).
2. Execute through the status period.
3. Retrieve initial "snapshot".
4. Compare actual finish dates to the initial "snapshot".

Program teams that can effectively manage the road ahead have a higher percentage of success. The intent of CEI is to focus the program team on ensuring the forecast schedule is accurate and then executing to it as effectively as possible.

Calculations

$$\boldsymbol{CEI = \frac{\#\ of\ tasks\ that\ finished\ in\ the\ window\ (of\ the\ tasks\ forecasted\ to\ finish)}{\#\ of\ tasks\ forecasted\ to\ finish\ in\ the\ defined\ window}}$$

Note: Tasks in this formula should exclude LOE and Summary lines (but should include all other tasks/milestones). Be careful when establishing the parameters of this metric, unlike BEI, the numerator should contain only tasks that were previously forecasted to finish and did finish in the defined window.

Example

37 = # of tasks forecasted to finish in the window

29 = # of tasks that finished in the window (out of the 37 forecasted to finish in the window)

CEI = 29/37 = .78

Optional Techniques

You can also measure "start CEI" using the start dates vice the finish dates.

Things to Promote

Good program management is good people management. The intent of this metric is to drive behavior by motivating and influencing the program team to focus on the accuracy and execution of the forecast schedule. By influencing the “soft” or “people” side of program management, the program team increases its chance of success.

Note: People will adapt their behaviors to succeed if they perceive success is measured. Changing people’s behavior creates new experiences that in turn create new attitudes. Over time, the new attitudes fuse into a new culture: a culture where program success is possible.

Things to Avoid

Work to keep CEI percentages above 80%. CEI percentages lower than 80% directly correlate to the program team’s ability to manage successfully.

Related Topics

Program Schedule Reviews
Statusing to Time Now
Forecasting
Business Rhythm

10.4.6 Total Float Consumption Index (TFCI)

Manager's View

Many duration-based schedule metrics capture status as a "moment in time" and do not consider what would happen if the program continued at its current rate of total float consumption   Total Float Consumption Index (TFCI) applies the schedule's average rate of total float consumption to the remaining scope of work and projects a forecast finish date of the entire project. Applying duration-based efficiency is analogous to applying a cost efficiency measurement to calculate an independent expected cost at the end of the project (IEAC).

Description

The focus of the TFCI is to provide a duration-based performance index calculating total float consumption as an efficiency factor. The TFCI can be used to assess the achievability of the project completion date in any network schedule rather than just using the total float as a static indicator of projected completion.   Program personnel use TFCI to estimate a projected forecast finish date.

$$TFCI = \frac{Project\ Actual\ Duration + Critical\ Path\ Total\ Float}{Project\ Actual\ Duration}$$

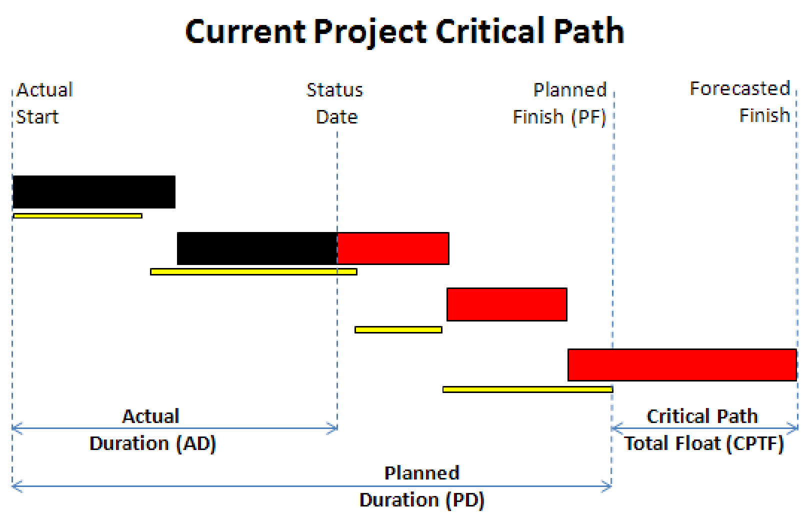


Figure 10.4.6-1 TFCI Components

Note: If the Critical Path Total Float is not being calculated to the baseline finish of the project, Baseline Finish Variance should be used in place of CPTF.

For any schedule using the critical path method, such as an IMS, total float is created or consumed based on network logic, completion of activities, and constraints within. This is commonly referred to as total float management. Managing a schedule by total float allows Applied Project Status to be quantified, Predicted Critical Path Total Float to be calculated, and a forecast finish date to be pinpointed. A TFCI of less than 1.00 indicates that a project may not complete on-time and applying that indicator to the total program duration (as depicted in steps #1 through #4 below) predicts where a project would complete if trends persist or corrective action is not taken.

Example

Step 1: Find the TFCI

How is the program doing so far? If the TFCI is below 1.0, then the program may not complete on-time without mitigation.

Project Actual Duration = span of actual working time accrued (in days or like unit of measure), from the beginning of the program through the status date.

$$\boldsymbol{TFCI = \frac{Actual\ Duration + Critical\ Path\ Total\ Float}{Actual\ Duration} = \frac{763 + (-23)}{763} = 0.97}$$

Step 2: Find Predicted Critical Path Total Float

This provides a quantitative assessment of future total float management using the total float consumed to date as an efficiency factor. How much total float will the project have by the baseline program finish date?

$$\boldsymbol{Predicted\ CPTF = Planned\ Duration\ (TFCI - 1) = 2351(.97 - 1) = -71\ days}$$

If the TFCI trend of 0.97 persists, then the project will be -71 days behind schedule at project completion instead of -23 days at the baseline program finish date.

Step 3: Find the Predicted Forecast Finish Date

Using the project calendar (which includes non-working days) add 71 working days to the baseline finish date to calculate a Predicted Forecast Finish date

$$\boldsymbol{Predicted\ \ Finish = BL\ Finish - PCPTF = Feb\ 16 - (-71\ days) = May\ 26}$$

Things to promote

Consider the Predicted Forecasted Finish date during EAC development.

Validate the TFCI metric results by utilizing other analysis techniques to investigate the cause of delinquent schedules and understand the implications for future project completion predictions.

Ensure the values used to calculate TFCI are adjusted to accommodate any differences between working and calendar days.

Things to Avoid

Avoid relying solely on this metric to determine the forecasted finish date. TFCI should not be used as a stand-alone assessment of projected project performance, but in conjunction with other tools such as schedule risk assessments.

Avoid skewing the results. TFCI is based in part on subjective forecasts and, as such, can be manipulated. If a project has a poor SPI, there is nothing that can immediately be done about it other than to start performing better so that future SPI is increased. TFCI, on the other hand, can be directly (and immediately) changed simply by modifying the forecasted completion of the critical path. In short, a poor TFCI can be improved without actually improving schedule performance.

The inclusion of any schedule buffer/margin in the IMS can complicate the calculation of TFCI because changes to total float cannot be suppressed for the metric to function properly.

Avoid exaggerating the predicted impact. TFCI functions on the premise that downstream forecasts are not adjusted based on past performance. If proper attention is given to accurate forecasting, TFCI can “double dip” the projected impact and predict a slip larger than past performance would suggest.

Depending on how the IMS is modeled, the CPTF may not ever be greater than zero, even if the project is forecasted to complete earlier than planned. Because of this, TFCI is intended to be used to analyze delinquent projects only.

An inherent property of the TFCI formula is early project instability. When a project is newly underway, its Actual Duration (AD) will be small. Since AD is the denominator of the TFCI equation, any change in CPTF in the numerator will have a magnified effect on the outcome of the metric. Because of this, less emphasis should be place on TFCI during the first few months of a project.

10.4.7 Duration-Based v. Scope-Based Percent Complete

Manager's View

Programs conduct Duration-based v. Scope-based Percent Complete analysis on in-process tasks during each status cycle. This analysis identifies in-process tasks that may not have sufficient time remaining to finish their incomplete scope. Programs should validate the forecasted finish date of each task that trips the analysis threshold to ensure the accuracy of the program's IMS.

Description

Percent complete v. Time Analysis compares the calculated time or duration-based percent complete with scope-based percent complete value (may be either Physical or Earned Value Percent Complete).

Example

Task Name	Time %	Scope %	Delta	Actual Duration	Remaining Duration
% Comp vs. Time - ERROR	**60%**			**30 days**	**20 days**
Conduct XYZ System Detailed Design	75%	40%	-35	30 days	10 days
Prepare for XYZ CDR	0%			0 days	10 days
XYZ CDR	0%			0 days	0 days
% Comp vs. Time - CORRECTION	**43%**			**30 days**	**40 days**
Conduct XYZ System Detailed Design	50%	40%	-10	30 days	30 days
Prepare for XYZ CDR	0%			0 days	10 days
XYZ CDR	0%			0 days	0 days

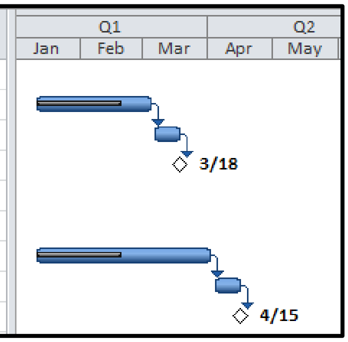


Figure 10.4.7-1 Results of identifying and adjusting duration to validate scope versus duration-based update

In this example (Figure 10.4.7-1), the "Conduct XYZ System Detailed Design" task has consumed 75% of the tasks time but only completed 40% of the scope. This results in a possible inaccurate forecast date of March 18th for the "XYZ CDR". The task owner assesses the task and determines that it is not possible to complete the remaining 60% of the task's scope in the remaining 25% of time. To resolve this unrealistic duration, the task owner may increase the task's remaining duration from 10 to 30 days, extending the forecast finish date of the task. This change flows through the network and results in a corrected forecast date of April 15th for the "XYZ CDR".

Calculations

Total Duration = Actual Duration + Remaining Duration

Duration Based % Complete = Actual Duration / Total Duration

Scope Based % Complete = task owners' assessment of % complete

- Could be a Physical % Complete or Earned Value % Complete

Note: If using Earned Value %-Complete to depict scope, understand that some Earned Value Techniques (i.e. Percent Start/Percent Complete) may distort the IMS analysis as the earned value performance may not be actually be equivalent to the task scope completed.

Things to Promote

Include an assessment of the remaining required resources on in-process tasks in conjunction with this analysis.

Examine task resource profiles when making duration versus scope analysis to ensure that remaining durations are consistent with the planned resource loads.

Related Topics

Statusing to Time Now
Forecasting
Managing using the IMS
Intro to Schedule Execution Metrics

10.4.8 Schedule Rate Chart

Manager's View

Schedule Rate Charts provide management with an easy to read overview of the program's task completion over time. The chart shows a trend line with the number of cumulative tasks Baselined, Forecasted, and Actually Finished at each status interval. The program team can use this chart to identify activity performance trends over time.

Description

Actual Finish v. Baseline Finish

Compare the number of cumulative tasks with Actual Finish dates in each past period to the number of cumulative baselined tasks planned to finish in the period. This indicates the difference between the planned and actual task completion rate. Programs conduct further analysis to understand the reasoning behind the variance, which could include the type of tasks, complexity of tasks, or resource availability.

Forecast Finish v. Baseline Finish

Compare the number of cumulative tasks with Forecasted Finish dates in each future period to the number of cumulative baselined tasks planned to finish in the period. This indicates the difference between the planned and forecasted task completion rate. Programs conduct further analysis to understand the reasoning behind the variance, which could include the type of tasks, complexity of tasks, or resource availability.

Bow Wave Analysis

A schedule bow wave occurs when tasks continually slip into the future. If this continues to happen as the program progresses, it could result in an insurmountable number of tasks forecasted for completion in one or more status periods. Programs should identify potential bow waves by comparing historical monthly completion rates to forecasted monthly completion rates.

Example

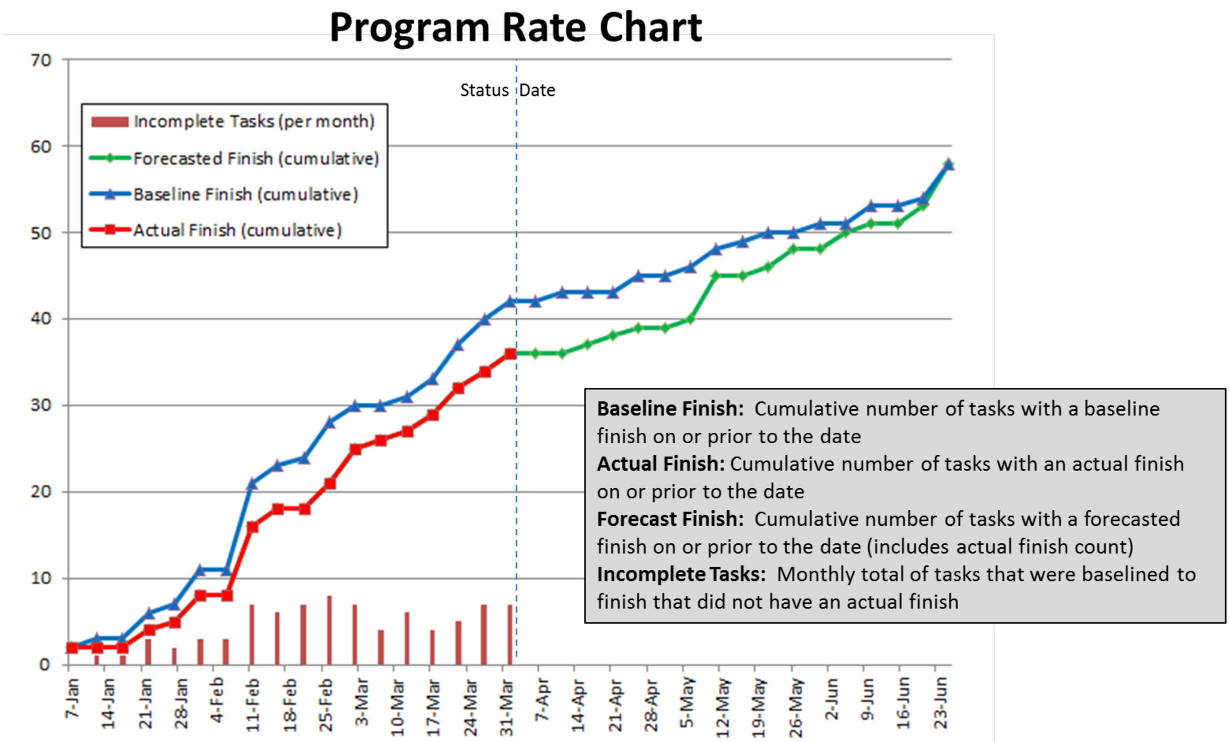


Figure 10.4.8-1 Program Rate Chart, showing actual data through March 31st, and ETC projections thereafter

Calculations

Actual Finish (Cumulative) – Total number of tasks with an Actual Finish prior to the end of the status period.

Forecast Finish (Cumulative) – Total number of tasks with Forecast Finish prior to the end of the status period.

Baseline Finish (Cumulative) – Total number of tasks with Baseline Finish prior to the end of the status period.

Incomplete Tasks (Status Period) – Number of tasks in the status period with an Actual Start date prior to the end of the status period and no Actual Finish date.

Things to Promote

Every task in the schedule has to be baselined for the chart to be useful

Rate Chart should be created based on a statused and validated IMS

Data in this chart should be analyzed and compared to the data in the SPI, CPLI, and BEI to make informed choices and drive action

Investigate and understand any unusual changes in the slope of the lines at or near "Time Now". Sharp inclines may be an indication of an unachievable "bow wave" of effort that has been allowed to accumulate.

Things to Avoid

Avoid including LOE, Summary tasks and repetitive CDRL delivery task strings in the Rate Chart as inclusion of these tasks may mask the performance of the discrete tasking. If Milestones are included, understand the impact they may have on the results.

Related Topics

- Task Duration
- Managing using the IMS
- Statusing to Time Now
- Forecasting

10.4.9 Time-Based Schedule Performance Index (SPI_t)

Manager's View

Time-Based Schedule Performance Index, or SPI_t, is a measurement of schedule efficiency. It is calculated from the exact same data as traditional SPI. The difference is that SPI is calculated off of the y-axis (typically in dollars) of the EV plot of Baseline Cost of Work Performed (BCWP) and Baseline Cost of Work Scheduled (BCWS), while SPI_t uses the x-axis (time) values. Like SPI, SPI_t is intended to be an early warning tool used to determine if the schedule is at risk.

Description

SPI_t is the Schedule Performance Index derived from Earned Schedule principles. The fundamental goal of SPI_t is no different than traditional SPI, which is to provide a measure of the schedule efficiency to which the IMS has been performed to date. SPI_t, however, overcomes the two fundamental obstacles inherent with traditional measures of SPI and Schedule Variance (SV):

1. SPI returns to 1.0 and SV returns to $0 at the completion of every project, regardless of whether planned commitment dates were met or not.
    - Causes SPI to be an ineffective measure of true project performance over the final 1/3 of the project.
2. Instead of measuring deviation from the IMS in units of time, traditional EV indices measure schedule variance in terms of dollars.
    - Results in an unintuitive method of assessing a deviation from the planned schedule.

Both SPI and SPI_t utilize the exact same BCWS and BCWP plots, as shown in Figure 10.4.9-1, except from different perspectives. Traditional SPI uses the y-axis ($) values of BCWS and BCWP, while SPI_t uses the x-axis (time). At project completion, the y-axis ($) values of BCWP and BCWS will be exactly the same, while the final x-axis (time) values can be considerably different depending on how early or late the project completed. By shifting the focus to time, SPI_t avoids both of the above problems, yielding accurate, intuitive, and actionable results through the entire life of the project.

Calculations

$$\boldsymbol{SPI(t) = \frac{Earned\ Schedule\ (ES)}{Actual\ Duration\ (AD)}}$$

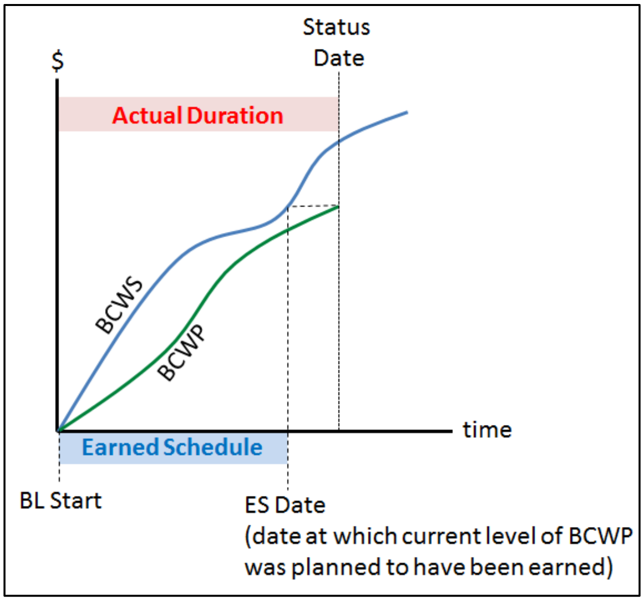


Figure 10.4.9-1 BCWP and BCWP for SPI(t) calculation

Earned Schedule (ES) - the amount of time that was originally planned (from the BCWS plot) to reach the current level of BCWP

- ES = ES Date – BL Start

Actual Duration (AD) - the amount of time that has elapsed to date

- AD = Status Date – BL Start

Resulting Values

Similar to SPI or BEI, a SPI_t value of 1.00 indicated the effort is progressing as planned (per the baseline). Values above 1.00 denote performance better than planned, while values below 1.00 suggest poorer performance than planned.

SPI_t Value	Implication
> 1.00	**Favorable** – The program on average is being accomplished at a faster than planned rate
= 1.00	**On Track** – The program on average is performing to plan
< 1.00	**Unfavorable** – The program on average is being accomplished at a slower rate than was planned

Figure 10.4.9-2 SPI_t Interpretation Guide

Periodicity

SPI_t, if used, should be calculated and analyzed after each Earned Value status period. For most programs, this is monthly, but may be more or less frequent depending on the effort or contractual requirement.

Things to Promote

Understanding the impact of LOE, this can skew SPI as it always earns BCWP in-line with BCWS.

As with BEI and SPI, SPI_t should be used in conjunction with sound critical path analysis, and never as a stand-alone indicator of the health of a program.

Related Topics

Schedule Performance Index (SPI)
Baseline Execution Index (BEI)
SPI_t v. $TSPI_t$
Independent Estimated Completion Date – Earned Schedule ($IECD_{es}$)
Critical and Driving Path Analysis

10.4.10 SPI_t v. $TSPI_t$

Manager's View

The To Complete Schedule Performance Index, or $TSPI_t$, is a calculation of the average projected schedule efficiency that will be maintained over the remainder of the effort. $TSPI_t$ can be compared to SPI_t as a check to see if future schedule efficiency is consistent with the schedule efficiency experienced to date.

Description

To Complete Performance Index (TCPI) is a well-known measure of the future cost efficiency needed to meet the project's Estimate at Completion (EAC). $TSPI_t$ is the scheduling counterpart to TCPI, as it is a measure of the future schedule efficiency that will be needed in order to meet the project's forecasted completion date.

Just as you expect the future cost efficiency of TCPI to be similar to the CPI that has been demonstrated to date, the forecasted schedule efficiency of $TSPI_t$ is generally expected to be in line with the SPI_t pace that has been demonstrated thus far in the project.

Calculations

$$SPI(t) = \frac{\text{Time planned to arrive at the current BCWP level}}{\text{Time it has actually taken}} = \frac{ES}{AD}$$

$$TSPI(t) = \frac{\text{Time planned to go from current BCWP to BAC}}{\text{Time we are now forecasting to do it in}} = \frac{PDWR}{RD}$$

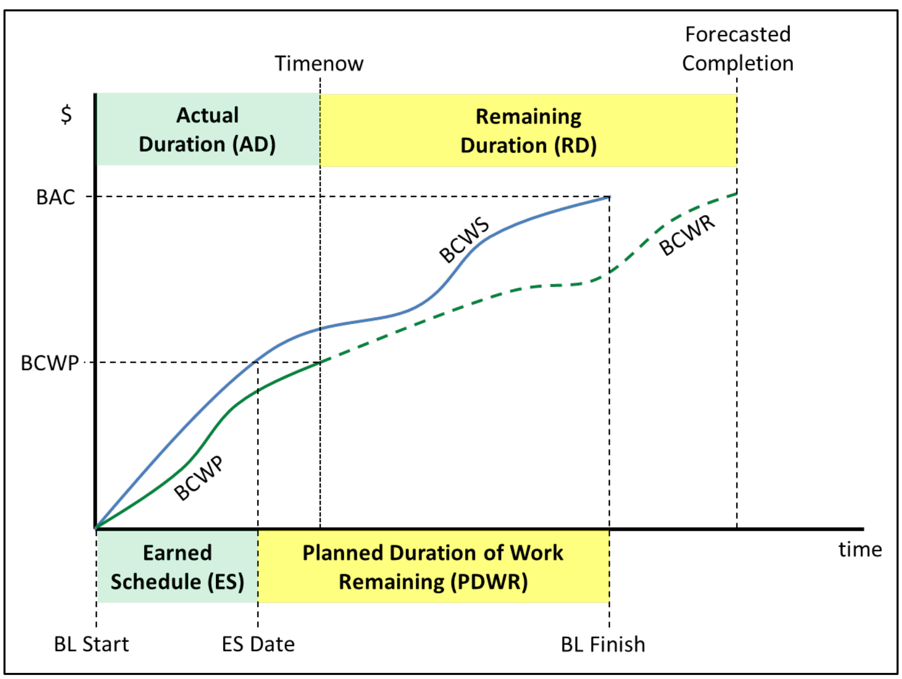


Figure 10.4.10-1 SPI_t and $TSPI_t$ calculations

Earned Schedule (ES) - the amount of time that was originally planned (from the BCWS plot) to reach the current level of BCWP

- ES = ES Date – BL Start

Actual Duration (AD) - the amount of time that has elapsed to date

- AD = Status Date – BL Start

Planned Duration of Work Remaining (PDWR) - the amount of time that was originally planned (from the BCWS plot) to complete the remaining scope of work

- PDWR = BL Finish – ES Date

Remaining Duration (RD) - the amount of time forecasted to complete the remaining scope of work

- RD = Forecasted Completion Date – Time Now

Resulting Values

Similar to CPI v. TCPI, the SPI_t v. $TSPI_t$ metric is intended to compare projected future performance to demonstrated past performance. CPI v. TCPI compares performance in terms of cost efficiency, while SPI_t v. $TSPI_t$ takes a schedule perspective. This metric differs from many others as it does not return a clear "pass/fail" result. Instead, it either increases or decreases the confidence in the forecasting accuracy of the IMS based on how close TSPI(ed) is to SPI_t.

The SPI_t v. $TSPI_t$ metric can be calculated at the control account or total program level. The threshold is set at 0.10 for this example but can be adjusted to meet surveillance requirements.

SPI_t - $TSPI_t$	Implication
-.10 to .10	**In Range** – downstream schedule performance is in line with the efficiency that has been demonstrated to date. While this does not guarantee the forecast accuracy of future deliverables, it does increase confidence in the IMS.
> .10	**Pessimistic** – may indicate an overly pessimistic forecast; that is, in this case, the estimate implies an expected drop in schedule performance for the remainder of the effort. It should be used as a flag for further investigation into the reasonableness of the forecast.
< -.10	**Unfavorable** – may indicate an overly optimistic forecast that implies an expected increase in schedule performance for the remainder of the effort. It should be used as a flag for further investigation into the reasonableness of the forecast.

Figure 10.4.10-2 SPI_t v. $TSPI_t$ Interpretation Guide

Periodicity

SPI_t v. $TSPI_t$, if used, should be calculated and analyzed after each Earned Value status period. For most programs, this is monthly, but may be more or less frequent depending on the effort or contractual requirement.

Optional Techniques

While the most common use of TCPI is to measure the cost efficiency needed to achieve the project's EAC, TCPI can also be used as a measure of the cost efficiency to meet the project's BAC ($TCPI_{bac}$). Similarly, $TSPI_t$ is most commonly used as a measure of the schedule efficiency needed to complete the project within the currently forecasted timeframe, but it can also be used to measure the schedule efficiency needed to complete the effort within project's baseline, or planned, duration. When both forms of $TSPI_t$ are used, a common nomenclature is TSPI(ed), for Estimated Duration, and TSPI(pd), for Planned Duration.

Things to Promote

Understanding the impact of LOE, this can skew SPI_t and $TSPI_t$ as it always earns BCWP in-line with BCWS.

SPI_t and $TSPI_t$ should be used in conjunction with sound critical path analysis, and never as a stand-alone indicator of the health of a program.

Things to Avoid

Avoid making definitive conclusions based on SPI_t and $TSPI_t$ values alone. Not all discrepancies between SPI_t and TSPI indicate an unreliable forecast, because there can be reasons to believe that past performance is not indicative of future results:

- Changes in staffing levels or proficiency
- Changes in facility capacity
- Changes in suppliers
- Changes in technology
- Performing an OTB/OTS.

Related Topics

Time-Based Schedule Performance Index (SPI_t)
Schedule Performance Index (SPI)
Independent Estimated Completion Date – Earned Schedule ($IECD_{es}$)
Critical and Driving Path Analysis

10.4.11 Independent Estimated Completion Date – Earned Schedule ($IECD_{es}$)

Manager's View

An Independent Estimated Completion Date (IECD) calculation takes past schedule performance and applies that rate to the remaining scope of the project to calculate a forecasted completion date. There are multiple ways to calculate an IECD. One of the most common methods uses Earned Schedule (ES) principles to determine the past schedule efficiency, in the form of the time-based Schedule Performance Index (SPI_t), and then applies that rate to the remaining effort to predict a completion date, or $IECD_{es}$.

Description

An evaluation of the critical path should yield the most accurate estimate of the project's completion date. That being said, the critical path is also very subjective. This is because the remaining duration of a project is determined by the duration of the tasks along the critical path – and those task durations are largely subjective assessments made by the task owner.

Conversely, an independent estimated completion date (IECD) does not rely on subjective forecasts, but instead uses actual schedule efficiency demonstrated to date and objectively applies that rate to the remaining scope of work to calculate a projected completion date. The trick is to find a consistently reliable measure of past schedule efficiency as well as an objective measure of the remaining scope. Both of these can be found by using the Earned Schedule principles discussed in the previous two sections. SPIt provides a measure of the schedule performance that has been demonstrated to date, while the Planned Duration of Work Remaining (PDWR) is the amount of time that was originally planned to accomplish the remaining scope of work.

Think of it this way; if you have been averaging 50 mph so far on your road trip and are 200 miles from your destination, when will you arrive? One way to answer that question is to assume the speed on the remainder of your trip will be the same as what you have averaged so far. So, if it is currently noon, then it should take you 4 hours to cover the remaining distance, which would have you arriving at 4:00 PM.

SPI_t is the "speed" that we have been averaging on our trip (project). PDWR is the "distance" we have left on our trip (project). By applying SPI_t to the PDWR, we can calculate an estimate of when our trip (project) will complete.

Note: While the acronym $IECD_{es}$ is used here for consistency with other nomenclature within this Guide, other acronyms such as "IEAC(t)" (time-based Independent Estimate at Completion) is also commonly used to represent the same calculation.

Calculations

$$\boldsymbol{IECD(es) = Timenow + \frac{PDWR}{SPI(t)}}$$

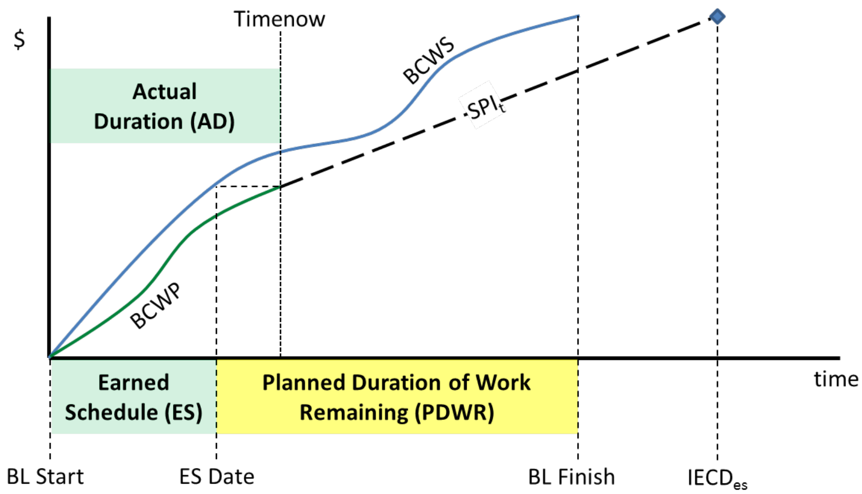


Figure 10.4.11-1 $IECD_{es}$ calculations

Earned Schedule (ES) - the amount of time that was originally planned (from the BCWS plot) to reach the current level of BCWP

- ES = ES Date – BL Start

Actual Duration (AD) - the amount of time that has elapsed to date

- AD = Status Date – BL Start

Planned Duration of Work Remaining (PDWR) - the amount of time that was originally planned (from the BCWS plot) to complete the remaining scope of work

- PDWR = BL Finish – ES Date

SPI_t – the actual schedule efficiency demonstrated to date

- SPI_t = ES/AD

Resulting Values

Unlike most metrics, there is not a “good” or “bad” $IECD_{es}$ date. Instead, the resulting date should be compared to the forecasted completion date from the IMS.

$IECD_{es}$	Implication
= Forecasted End Date	**In Range** – the future efficiency forecasted in the project schedule is consistent with the schedule efficiency experienced to date
< Forecasted End Date	**Pessimistic** – the future efficiency forecasted in the project schedule is slower than the schedule efficiency experienced to date
> Forecasted End Date	**Optimistic** – the future efficiency forecasted in the project schedule is faster than the schedule efficiency experienced to date

Figure 10.4.11-2 $IECD_{es}$ Interpretation Guide

Periodicity

$IECD_{es}$, if used, should be calculated and analyzed after each Earned Value status period. For most programs, this is monthly, but may be more or less frequent depending on the effort or contractual requirement.

Things to Promote

Investigate differences between the $IECD_{es}$ and the forecasted completion date from the IMS to understand why future performance is better or worse than what has been experienced to date.

Things to Avoid

$IECD_{es}$ should not be used as a substitute for sound critical path forecasting.

Related Topics

Time-Based Schedule Performance Index (SPI_t)
SPI_t v. $TSPI_t$
Critical and Driving Path Analysis

11 Business Rhythm and Submittal

This section contains the following chapters.

11.1 IMS Supplemental Guidance

Manager's View

The IMS Supplemental Guidance is a communication tool that accompanies the IMS with an intended audience of new program personnel, auditors, and customers. Its objective is to assist the user in understanding the construct and specifics of the IMS as the program's forward-looking predictive model. It defines the structure and data resident within the IMS, the methodology for vertical and horizontal traceability, and the update, maintenance, and analysis processes.

Description

The following table (Figure 11.1-1) contains an *example* list of recommended elements for inclusion in the IMS Supplemental Guidance.

Element	Description
IMS Construct	
Data Dictionary	A table that defines the format and location of fields defined by the user in the IMS.
Risks and Opportunities	Defines of how risk mitigation plans and opportunity capture plans are traceable to the IMS.
Schedule Software Configuration Options	Lists the configurable settings used by the program's schedule management team in the scheduling software tool.
Resource Loading	Defines how the IMS is resource loaded and/or traceable to the Earned Value System.
Calendars	A table or series of tables, depicting the non-working days or times in the program, activity, and/or resource calendars used in the IMS.
Schedule Margin	Defines how the management of schedule margin in the IMS is accomplished
Schedule Baseline	Defines how the schedule baseline is constructed. Defines how the Rolling Wave decomposes Planning Packages into tasks within the IMS.
Basis and Assumptions	Captures the assumptions made during the creation of the IMS by the task owners.
Vertical and Horizontal Traceability	
Constraints, Lags/Leads	Defines how to use constraints, leads, and lags in the IMS.
Relationship Types	Defines how the program is using the various logical relationship types

Element	Description
Schedule Hierarchy	Defines how the Master Summary, Intermediate, and Detail level schedules are vertically traceable.
Program Milestones	Lists the key program milestones defined in the IMS.
Control / Toll Gate Milestones	Defines the use of control and toll-gate milestones within the IMS.
External Schedule Integration	Defines the integration methods used with external schedules (i.e. subcontractors and partners). Document IMS related requirements flowed down to subcontractors.
Schedule Visibility Tasks (SVTs)	Defines the use of “Schedule Visibility Tasks” (SVT) in the IMS.
Statement of Work (SOW)/Objectives (SOO)/Requirements (SOR)	Defines how each Statement of Work (SOW), Statement of Objectives (SOO), Statement of Requirements (SOR) paragraph is traceable to the IMS.
Work Breakdown Structure (WBS)	Defines how the Work Breakdown Structure(s) (WBS) are traceable to the IMS.
Organizational Breakdown Structure (OBS)	Defines the traceability of the Organizational Breakdown Structure (OBS) in the IMS.
Earned Value Techniques (EVT)	Defines the usage of “Earned Value Techniques” (EVT) in the IMS. This element should include an explanation of the usage of Level of Effort and Apportioned Tasking in the IMS.
Integrated Product Teams	Defines how the Integrated Product Teams (IPTs) are traceable to the IMS.
Control Account Managers	Defines how the Control Account Managers (CAMs) are traceable to the IMS.
Integrated Master Plan	Defines how the IMS is traceable to the Integrated Master Plan (IMP)
Control Account	Defines how the IMS is traceable to the Control Accounts.
Work Package	Defines how the IMS is traceable to the Work Packages.
Update and Analysis	
Business Rhythm	Defines how the weekly, monthly, and quarterly (as applicable) status, maintenance, analysis, and review is performed on the IMS.
IMS Health Assessment	Defines the process usage of the IMS Health Assessment process by the schedule management team.

Element	Description
Schedule Risk Assessment (SRA)	Defines the process governing the use of the Schedule Risk Assessment (SRA) process by the program.
Schedule Execution Metrics	Defines how Schedule Execution metrics may be used by the program team to make management decisions. This may include standard views, filters, and analysis packages used in analysis and recurring program reviews.
Critical and Driving Path Methods	Defines the program's methods and processes for Critical and Driving Path analysis.
Submittal Requirements	Defines the program's IMS related submittal requirements.

Figure 11.1-1 Example List of recommended elements in a Program's IMS Supplemental Guidance documentation

Optional Techniques

Programs could capture these elements in the IMS Desktop Procedures. However, the program may lose the benefit of IMS Supplemental Guidance as a communication vehicle as the level of detail in a Desktop Procedure is typically very low.

Programs could also manifest these elements as part of the Program Plan, Program Management Plan, or Program EVMS Plan. Programs could also refer to this document as a Schedule Management Plan or Procedure (SMP).

Things to Promote

Ensure to keep the IMS Supplemental Guidance up to date with changes to the IMS structure and management process.

Include the IMS Supplemental Guidance in submittals of the IMS and IMS related analysis (as appropriate).

Include the IMS Supplemental Guidance as a reference in audit in-briefs and data calls.

Keep the guide as concise as possible. This is best accomplished by refraining from recreating standard processes described elsewhere unless they provide a unique or essential understanding to the specific IMS being submitted.

Things to Avoid

Avoid submitting the IMS or conducting and IMS audit in-briefing without a clearly defined overview of the IMS structure and management process.

Related Topics

Managing using the IMS
Intro to Schedule Execution Metrics
Desktop Procedures

11.2 Desktop Procedures

Manager's View

Document and control all activities associated with the preparation, use, and maintenance of the Integrated Master Schedule (IMS). Desktop procedures ensure consistent standardized scheduling and continuity of processes and procedures across all personnel in the event of personnel changes. These procedures align and support higher-level procedures and directives such as the IMS Supplemental Guidance, the Program Management Plan (PMP), Subcontract Management Plan, and the EVM System Description.

Description

Desktop Procedures contain the detailed steps that personnel employ to prepare, use, and maintain an IMS. Desktop procedures come in many forms. They may be checklists, program unique instructions, scheduling supplemental guidance, or even sections in the EVMS Description document. The extent of desktop procedures needed varies based upon the procedures documented at the various levels of the organization.

Some candidates for Desktop Procedures include:

- IMS schedule development
- Application of work templates networks in IMS development
- Preparation of PM IMS analysis information
- IMS data element trace procedures
- Procedures for customer unique schedule reports
- Procedures to develop/update resources and rate tables in IMS
- Export of IMS data into Work Authorization documents
- Extracting Control Account Plans and other reports for CAMs
- Procedures for schedule health metrics IMS preparation for customer submittal
- Risk Management analysis and reporting
- Preparation of IMS data for import to EVMS Cost System
- CAM inputs to schedule updates
- IMS Update procedures
- IMS inputs and procedures to support ETC and EAC estimates
- Incorporation of approved baseline changes
- Preparation of proposed schedule changes (BCRs, SCRs, BARs, CRs, etc.)
- Rolling wave planning procedures
- Integrating Subcontractor Schedules into the Prime IMS

Example

Below are examples of the hierarchy of IMS direction and guidance in a large corporation through desktop procedures:

- Corporation EVMS Description – Containing general requirements for IMS preparation content and coding.
- Business Division Scheduling Methodology Document – Standardizing scheduling techniques templates and tools across all schedulers.
- IMS Supplemental Guidance – Defines the structure and data resident within the IMS, the methodology for vertical and horizontal traceability, and the update, maintenance, and analysis processes.

- Position or Task Unique desktop procedures – Procedures for CAMs to use when updating the schedule, procedures to perform what-if analysis with IMS on baseline change requests and procedures to validate the IMS before importing information into the EVMS cost system.

Optional Techniques

Place all IMS related desktop procedures in program supplemental scheduling guidance or in a program unique scheduling instruction. Allow usability features to dictate procedure's media and format. For example, web-enabled procedures may prove beneficial to some organizations while handwritten checklist may suffice for others.

Things to Promote

Management performs a desk audit for all personnel that touch or use the IMS. Ensure they each have documented procedures for their activities.

Management collects, reviews, and controls all desktop procedures. Have all IMS stakeholders review and coordinate on all IMS desktop procedures.

Have a plan for periodic review and update of desktop procedures. Use feedback to identify process changes to the Desktop Procedure. Monitor to ensure these process changes result in measurable performance.

Update processes based on lessons learned analysis at program completion

Things to Avoid

Allowing personnel using the IMS to have unaudited and uncontrolled procedures.

Avoid not having a desktop procedure for any recurring task, process or procedure crucial to a program.

Related Topics

Business Rhythm
Roles and Responsibilities of Program Personnel
Planner/Scheduler Skills and Training

11.3 Submittal of IMS Data

Manager's View

A program's Integrated Master Schedule (IMS) contains a large number of data elements used for program performance and predictive analysis in addition to establishing horizontal and vertical integration. Many of these data elements may be in addition to the fields natively found in scheduling software. It is important for both the contractor and government teams to understand and agree to the frequency, format, and content of the submitted IMS data and analysis. This enables a common understanding of the IMS and helps to ensure that the IMS related contractual obligations are satisfied.

Description

Frequency

It is recommended that the program IMS be formally submitted:

- In conjunction with Cost Performance Report (CPR) or Integrated Program Management Report (IPMR) Data Item Description (current version), cost data submittal requirements (Formats 1 to 5 and IPMR Format 7) to ensure consistent data are available for recurring cost and schedule performance analysis.
- If the program does not require Earned Value Management, then submit the IMS in concert with other program performance reports.
- In the absence of any cost performance reporting requirements, submit the IMS monthly on development type contracts and less frequently on non-development type contracts that require the use of an IMS.

Note: Consider the duration of the work effort as well as the level of program risk and complexity when determining the frequency of IMS status updates, analysis, and reporting. IMS CDRL tailoring may be made during the negotiations between the prime and customer and upon approval, documented in the CDRL requirements.

Format

It is recommended that the IMS be submitted in both its native scheduling software format and the software neutral UN/CEFACT IMS XML or JSON schema format, as required by CDRL.

The UN/CEFACT IMS XML schema format uses an open source XML data schema published by the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT). An XML schema is an open source structured text format designed to efficiently facilitate data exchanges and other uses. It is a carrier of raw data and therefore not meant to be human readable, although it is a text file. The structure is such that an XML expert can easily create an XML file and/or read an XML file and convert it to whatever other data structure (database files, spreadsheets, etc.) the receiving end requires. XML does not require a license to create or read, making it a standard, world-wide solution for many applications.

JavaScript Object Notation (JSON) is a lightweight data-interchange format that is easy for humans to read and write and for machines to parse and generate. It is based on a subset of JavaScript Programming Language. JSON is a text format that is completely language independent but uses conventions that are familiar to programmers of the C-family of languages. These properties make JSON an ideal data-interchange language.

The UN/CEFACT XML and JSON schemas enable the ability to transfer data between various schedule software tools. It identifies a normalized set of schedule data elements and is designed to help exchange schedule data between parties regardless of the schedule toolsets that may be used at either end.

The complete UN/CEFACT data library can be found on the UN/CEFACT web site: http://www.unece.org/cefact/index.html.

Note: At this point there are unmitigated differences in the schedule algorithms between scheduling software tools. In many cases moving schedule information whether in part or full can result in deltas when the schedule is calculated. Therefore, contractors and government personnel, who are attempting to use two different software tools for schedule management, should clearly understand the configurable options and the potential deltas that may occur.

The DoD Office of Acquisition, Analytics and Policy: Earned Value Management (AAP-EVM) has published a set of data exchange instructions (DEIs) that provide specifics on how to use the schemas to produce an XML or JSON instance file that reflects the data requirements identified in the DoD CPR, IMS, and IPMR Data Item Descriptions (DIDs). Any end user proficient in XML or JSON or any software vendor can use these data exchange instructions as the basis to produce, parse (read or extract), or transform an XML or JSON instance file that follows the applicable data exchange instruction.

The schedule data exchange instruction for the IMS DID or the IPMR DID Format 6 is a multi-tabbed file that includes Data Requirements Guidelines, Task Coding Guidelines, Data Type, and Complex Data Type coding details useful for a technical end user who wishes to produce or use an XML or JSON instance file that follows the schedule data exchange instruction.

Note: The Data Item Descriptions always govern the contractual data requirements. The data exchange instructions are designed to reflect the data requirements specified in the DIDs.

The complete set of data exchange instructions, example XML instance files, and XML file viewer tools can be found on the Defense Cost and Resource Center (DCARC) EVM Central Repository website: http://dcarc.cape.osd.mil/evm/Uncefact.aspx.

Various commercial off the shelf (COTS) vendors have used the data exchange instructions to provide end users with the ability to import and export schedule data using the UN/CEFACT schemas. For these software vendors, the UN/CEFACT XML or JSON are just another import and/or export option within their software. The utilities in the software either produce an XML/JSON instance file and/or provide the ability to import an XML/JSON instance file that follows the data exchange instructions.

Data Element Recommendations – Native Fields

The following tables contain a list of recommended native Project (Figure 11.3-1), Activity (Figure 11.3-2), and Resource (Figure 11.3-3) schedule fields for inclusion in the IMS submittal. The titles of these data fields may vary slightly between the scheduling software tools.

Note: if the IMS is not resource loaded then the associated resource and cost fields would not be available for submission.

Project Fields - Native	
Start Date	End Date
Status Date (Time Now Date)	Calendar

Figure 11.3-1 Sample recommended list of Native Project Fields to be included in a submittal IMS

Activity Fields - Native		
Unique Identifier	Free Float / Free Stack	Successor
Name/Description	Start (i.e. Early/Forecast)	Lag / Lead
Duration	Finish (i.e. Early/Forecast)	Relationship Type (i.e. FS, SF, SS, FF)
Baseline Duration	Late Start	Calendar
Remaining Duration	Late Finish	Constraint Type
Actual Duration	Baseline Start	Constraint Date
Finish Variance	Baseline Finish	Percent Complete (Calculated / Duration Based)
Start Variance	Actual Start	Type (i.e. Task, Milestone, Hammock)
Duration Variance	Actual Finish	Predecessor
Total Float / Total Slack		

Figure 11.3-2 Sample recommended list of Native Activity Fields to be included in a submittal IMS

Resource Fields – Native		
Unique Identifier	Calendar	Type (labor / non-labor)
Baseline Amount (direct cost)	Estimated Amount (direct cost)	Actual Amount (direct cost)
Baseline Quantity (hour or unit)	Estimated Quantity (hour or unit)	Actual Quantity (hour or unit)
Baseline Cost	Estimated Cost	

Figure 11.3-3 Sample recommended list of Native Resource Fields to be included in a submittal IMS

Data Element Recommendations – Custom / Defined by User Fields

The following table (Figure 11.3-4) contains a list of recommended custom / defined by user fields for inclusion in the IMS submittal.

Activity Owner (Control Account Manager)	Schedule Risk Assessment – Distribution Curve
Planning or Work Package Identifier	Schedule Risk Assessment – Reporting Task
Integrated Product Team (IPT)	Schedule Risk Assessment – Minimum Duration

Organizational Breakdown Structure (OBS)	Schedule Risk Assessment – Most Likely Duration
Work Breakdown Structure (WBS)	Schedule Risk Assessment – Maximum Duration
Statement of Work (SOW) Paragraph	Earned Value Technique
Control Account Identifier	Earned Value Percent Complete
Multi-Project Unique Identifier	Physical (Scope Based) Percent Complete
Government Furnished Equipment / Information	Justification of Lags/Constraints
Integrated Master Plan Identifier	Subcontract Identifier
Risk and Opportunity Codes	Critical and Driving path Indicators
Schedule Visibility Task (SVT) Identifier (may be built into task name)	Schedule Margin Code (may be built into task name)

Figure 11.3-4 Sample recommended list of fields defined by the user for inclusion in an IMS submittal

IMS Narratives

Ensure that an IMS Narrative and an IMS Supplemental Guidance document (see IMS Supplemental Guidance chapter in this guide) accompany the IMS submittal. The IMS Narrative should include the following items:

- **Critical and Driving Paths:** an analysis of at least the top three critical and driving paths
- **Finish Variance:** a discussion of Finish Variance (in this case the delta between the Forecast Finish date and the Baseline Finish date on the last task in the network) at the total contract level in days.
- **Schedule Margin:** a discussion of any changes in the duration (baseline or forecast) of schedule margin (if applicable).
- **Data Dictionary:** a discussion of any changes to the data dictionary (including task activity codes)
- **Schedule Health:** a discussion of any internal schedule health assessments (if applicable)
- **Schedule Changes:** a discussion of any major changes to the schedule including significant changes to the baseline schedule, working calendars, resource utilization, or execution strategy

Examples

IMS Narratives - Critical and Driving Paths

An example of this analysis might contain a screen shot of the path in question and a narrative with the following elements:

1. What? – A brief explanation of the situation
2. So What? – The impact of the situation on the program

3. Now What? – The steps being taken to mitigate the situation including any requested customer help

The following is an example (Figure 11.3-5) IMS Narrative analysis for the primary driving path to a program's next major milestone.

Driving Path Screenshot

Task Name	Early Start	Early Finish	Late Start	Late Finish	Total Float
Driving Path Example	**1/11**	**4/4**	**1/11**	**3/29**	**-4 days**
Conduct Product Environmental Testing	1/11	2/29	1/11	2/29	-4 days
Hold Flight Test Readiness Review	3/1	3/7	2/24	3/1	-4 days
Perform Flight Test	3/8	4/4	3/2	3/29	-4 days
XYZ CDR	4/4	4/4	3/29	3/29	-4 days

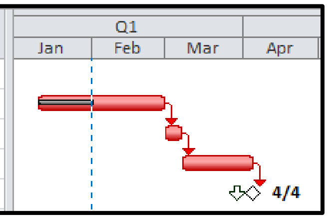


Figure 11.3-5 Example Driving Path Screenshot

Driving Path Narrative

The IMS indicates the forecast date for the next test flight is 4 days after its target date due to an overlap of program assets that require testing in the environmental lab. This test flight slip will not impact the overall program as additional test engineers are being brought on to decrease the duration needed to conduct post-test analysis and report generation. However, the contractor is requesting assistance in ensuring the test range is available on the current forecasted dates. To ensure that no future slips occur, the program team will closely monitor environmental lab needs and schedule multiple shifts to mitigate any potential overlaps.

The following is an example (Figure 11.3-6) IMS narrative analysis to the program end's critical path.

Critical Path Screenshot

Task Name	Early Start	Early Finish	Late Start	Late Finish	Total Float
Critical Path Example	**1/18**	**11/15**	**1/18**	**12/5**	**14 days**
Determine GNC Build 1 Requirements	1/18	2/10	1/18	3/1	14 days
Conduct GNC SW Build 1 Design	2/11	3/16	3/2	4/5	14 days
Code GNC SW Build 1	3/17	3/30	4/6	4/19	14 days
Conduct GNC SW Build 1 Unit Test	3/31	4/13	4/20	5/3	14 days
Determine GNC Build 1 Requirements	4/14	5/9	5/4	5/27	14 days
Conduct GNC SW Build 1 Design	5/10	6/13	5/30	7/1	14 days
Code GNC SW Build 1	6/14	6/27	7/4	7/15	14 days
Conduct GNC SW Build 1 Unit Test	6/28	7/11	7/18	7/29	14 days
Determine GNC Build 1 Requirements	7/12	8/4	8/1	8/24	14 days
Conduct GNC SW Build 1 Design	8/5	9/8	8/25	9/28	14 days
Code GNC SW Build 1	9/9	9/22	9/29	10/12	14 days
Conduct GNC SW Build 1 Unit Test	9/23	10/6	10/13	10/26	14 days
GNC SW Build Complete	10/6	10/6	10/27	10/27	14 days
Conduct Final SW Integration and Test	10/7	11/8	10/27	11/28	14 days
Deliver Final Program SW Build	11/9	11/15	11/29	12/5	14 days
Program End	11/15	11/15	12/5	12/5	14 days

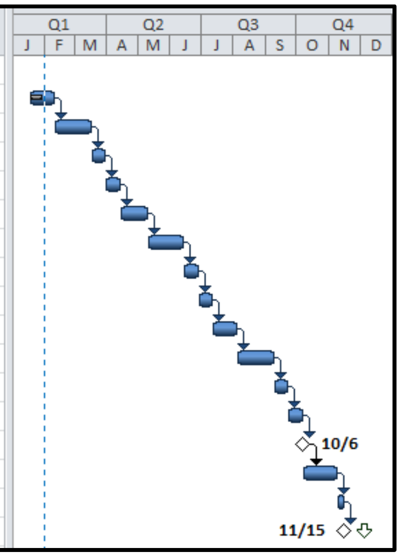


Figure 11.3-6 Critical Path Screenshot to accompany the IMS narrative

Critical Path Narrative

The program currently has 14 of the original 20 days of calculated total float remaining in the critical path. Six days of calculated total float were lost due to clearance requirements holding up key software developers. The program currently has all required assets cleared to the program, is forecasting an early completion date, has accepted the total float loss and anticipates no further delays.

Related Topics

Managing using the IMS
Intro to Schedule Execution Metrics
IMS Supplemental Guidance

11.4 Business Rhythm

Manager's View

Successful programs establish, execute, and follow a business rhythm for the status, maintenance, and analysis of the IMS. Establishing this rhythm early in the program creates the momentum that keeps the program processes on track, creating an environment of on-time work completion at a regular and consistent pace. The Program Manager and the Leadership Team create this rhythm by establishing and following a standard business calendar that lays out regular IMS updates and program status reviews.

Description

A typical business rhythm calendar shows the activities that occur on a recurring cycle, coinciding with the financial and customer reporting cycles. The examples below represent typical recurring activities on a typical business calendar. Programs also have the option of implementing a weekly calendar showing regularly scheduled meetings, reviews, and other program activities. These calendars augment the IMS providing regularly scheduled details associated with managing both the program and the schedule. Establishing this rhythm early in the program life cycle establishes the discipline and sense of importance necessary to motivate the program team to work to the IMS and complete work regularly and on time.

A key purpose for the Business Rhythm Calendar is to ensure that intermediate products are available for review and validation. This ensures that the integrity of all of the inter-related systems is current. Late reviews of intermediate products typically affect the validity of downstream products so programs should ensure timeliness in the production and review of intermediate products.

Some programs will also establish weekly or bi-weekly status updates and review of the IMS to enhance the management style. The advantage to more frequent IMS updates is that the program team can better monitor progress and implement corrective actions before the program realizes schedule impacts. Programs should weigh the advantage of more frequent IMS updates against the extra burden and cost associated with the maintenance of the schedule in addition to ensuring that it affords sufficient time for analysis.

On programs with less frequent IMS status updates and review, a look-ahead schedule showing only tasks relevant for the upcoming weeks is a useful tool for weekly program meetings to address areas that require immediate focus.

Examples

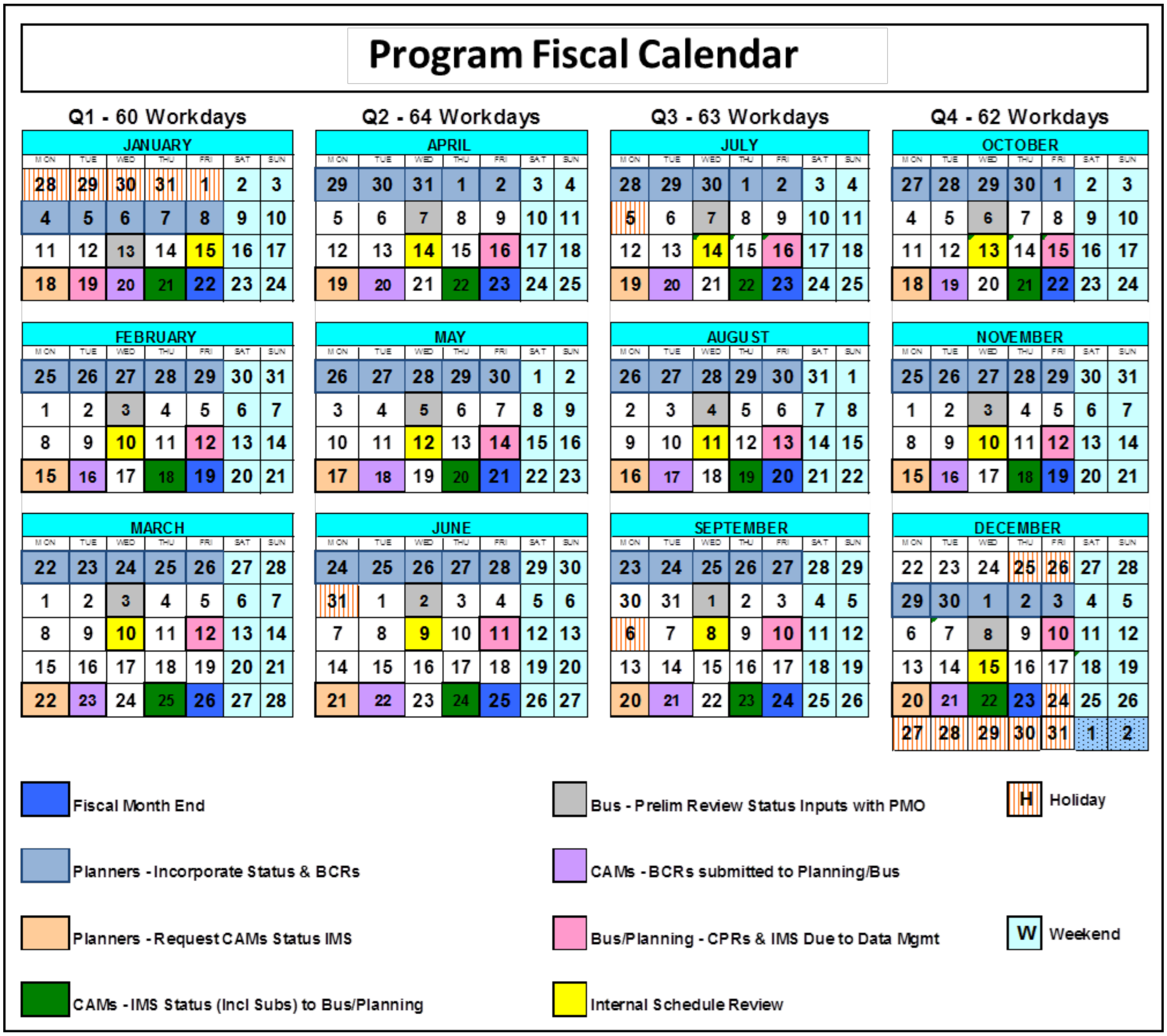


Figure 11.4-1 Sample Program Fiscal Calendar

Sample Program Weekly Calendar

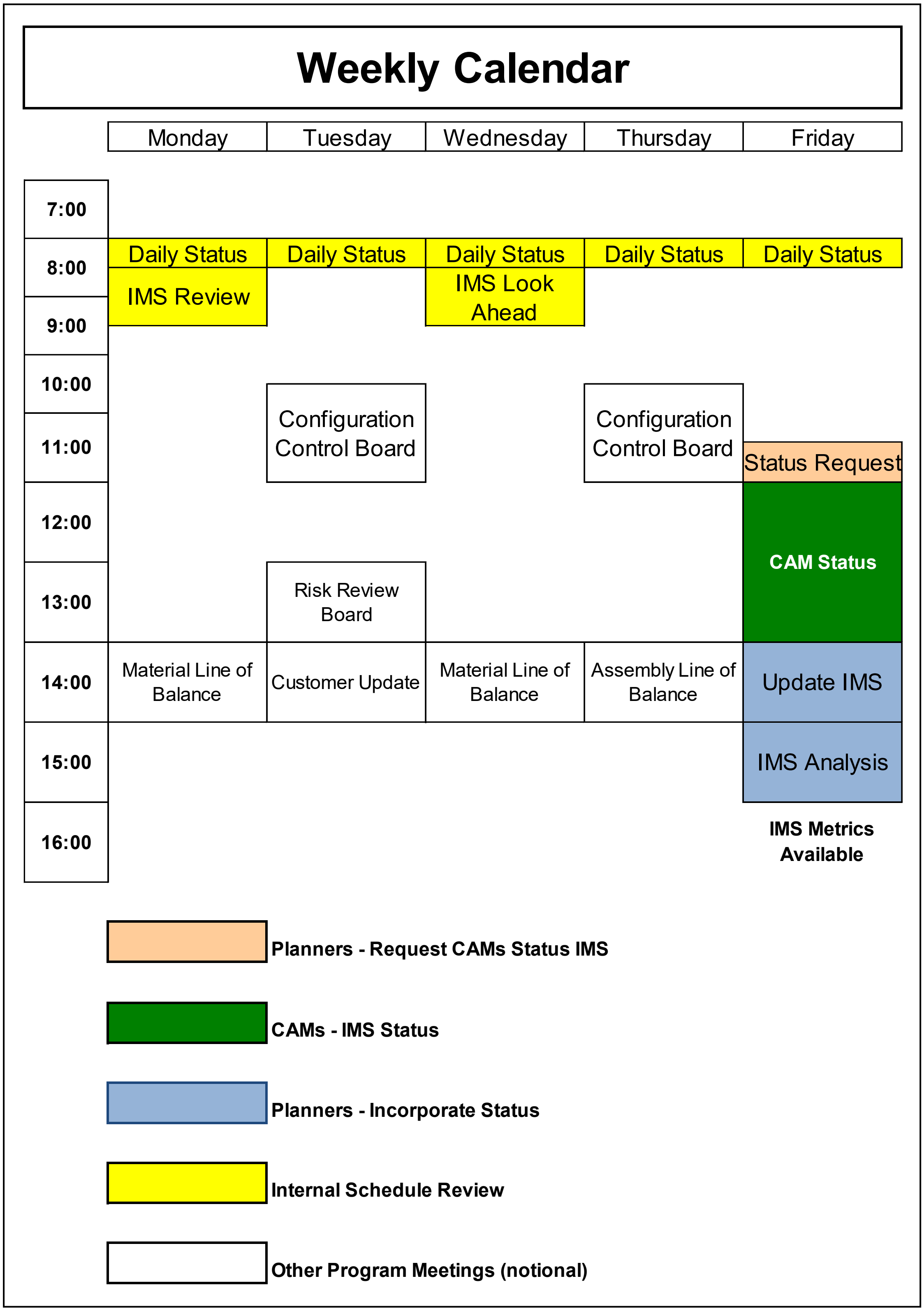


Figure 11.4-2 Sample Weekly Program Calendar

Things to Promote

Leave flexibility in the business rhythm for the program team to analyze and implement corrective actions. Business rhythm includes actions and deadlines necessary for all relevant stakeholders, not just IMS related activities.

Ensure the management process includes methods to address actions that cannot be resolved within the current reporting cycle.

Establish back-ups for individual roles within the business rhythm to support extended periods of absence from the team.

Establish and follow a formal IMS status process that is fast and effective.

Ensure the program business rhythm contains a comprehensive schedule review. Refer to the Program Schedule Reviews chapter in this guide.

Things to Avoid

Avoid deviating from the business rhythm due to conflicting programmatic commitments.

Avoid using a program calendar that is out of alignment with the company's financial calendar.

Avoid spending more time getting status updates and discussing the IMS than getting work done. There needs to be the correct balance with regard to the time spent updating status and evaluating the IMS.

Related Topics

Forecasting
Baseline Change Management
Managing using the IMS
Program Schedule Reviews

11.5 Program Schedule Reviews

Manager's View

Recurring Program Schedule Reviews provide information on past performance, present status and future schedule projections. These reviews focus dedicated attention to program status. Special attention is required to the progress of tasks on the Program Critical Path and near Critical Path and associated Total Float. In addition, past due tasks to Key Program Milestones and newly identified schedule risks and opportunities require Program Management consideration. This forum allows the customer and contractor program managers to work collaboratively, accepting responsibility and ownership of the IMS with the objective of making joint decisions based on program performance and objectives.

Description

Program Schedule Reviews may be a stand-alone meeting focusing only on the IMS or have scheduling integrated as a topic reviewed regularly at the Program Management Meeting. Regardless of the forum, these meetings should provide a consistent approach for reviewing schedule information and should occur on a regular basis based on the size and complexity of the program. The data for the schedule review is from the Program IMS including status. The meeting will review the schedule reports described in the following example:

Example

The following table contains a list of representative examples for inclusion in program schedule reviews.

IMS Analysis/Metric	Management Value
Summary Master Schedule (i.e. Master Phasing Schedule)	Provides a summary level graphical overview of the program schedule
Schedule Margin Status	Identifies the current amount of calculated schedule margin to both interim milestones and program completion
Critical/Driving Path Analysis	• Identification of current and future critical and driving tasks that require management attention now • Provides a framework for proactive management of downstream risks • Quantifies the amount of time flexibility available to every program task • Includes Finish Variance to key programmatic reporting milestones
Status Window Reports	• Identifies forecasted changes made since the last status period • Includes Current Execution Index (CEI) • Includes an overview of significant achievements made in the status window
Look Ahead Analysis	• Identifies activities scheduled to start in the near term (i.e. 30, 60 or 90 days in the future)

IMS Analysis/Metric	Management Value
	• Quantifies the amount of time flexibility available to near term tasks
Schedule Risk Assessment (SRA) (Histogram, Sensitivity Analysis, Criticality Analysis to a key program milestone and program end)	• Predicts probability of program completion by date • Identifies tasks with a high probability of becoming critical • Helps to mathematically quantify program risk and opportunity
Critical Path Length Index (CPLI)	Measures how realistic the program completion date is and the efficiency rate required to complete the program as planned
Baseline Execution Index (BEI)	Reveals the "execution pace" for a program and provides an early warning of increased risk to on-time completion
Schedule Performance Index (SPI)	Provides an early warning based on past performance to determine if the schedule is at risk and increased performance will be needed if the program is to complete on time
Current Execution Index (CEI)	Measures how accurately the program is forecasting and executing to its forecast from one period to the next
Total Float Consumption Index (TFCI)	Used to assess the reasonableness of the forecasted project completion date based on float consumption trends to date
Schedule Rate Charts	• Compares task completion rates to plan • Identifies forecast "bow waves"
Duration v. Scope Based %	Validates accuracy of in-process task finish dates and ETC resource forecasts
Resource De-Confliction Analysis	• Identifies requirement conflicts and overlaps for key program resources (including people, places, and things) • Quantifies program staffing needs
Upcoming Giver/Receiver Hand-offs	Aids in communicating Hand-offs between program stakeholders
Program Schedule Risks	Should provide an update on program schedule risks identified in the program Risk Management process.
External Impacts	Identifies status of key supplier schedule impacts and a status of Government Furnished Items (GFx)
Performance Measurement Baseline Changes	Summarizes major changes to the programs Performance Measurement Baseline (PMB) (i.e., Replans, Reprograms, Rolling Waves)

Figure 11.5-1 Example Items for Program Schedule Reviews

Integrated Baseline Reviews

Programs undergo Integrated Baseline Reviews (IBRs) shortly after contract award. The objectives of the IBR is to ensure both the contractor and customer validate that the established baseline (technical, schedule and cost) is executable within the cost and schedule constraints of the contract and with an acceptable level of risk. Additionally, the IBR should demonstrate the program's technical (scope), schedule, cost, resource, and general management processes. Finally, the IBR will cover roles and responsibilities of program personnel and a status on required technical expertise. Contractors and customers should clearly define the expectations and assumptions of the IBR content to ensure an efficient and effective IBR. Address IBR actions identified in the IBR out-brief quickly.

Optional Techniques

Contract Data Requirements List (CDRL) Deliverables – Consider reviewing the CDRL's during Program schedule reviews. This report aids in keeping the contractual deliveries in the management team's focus. The data manager typically oversees the delivery and status of the program CDRLs. Identifying and tracking program CDRLs in the IMS is an effective method of tracking progress and accomplishment required to identify problem deliverables or issues.

Things to Promote

Focus program schedule reviews on relevant schedule information that the PM and Program Management Team need to make proactive decisions and take corrective action should an issue arise. The IMS will reflect past performance but should also provide the information necessary to guide the decisions to manage the remaining work to meet the key program milestones including program completion. During these meetings, it is essential for the Team Leaders to understand both the program summary schedule information and their team schedule data, be able to explain it to the PM during these meetings and be accountable in managing their portion of the Program.

Ensure that the program schedule accurately reflects the program performance to date and that the remaining task durations and relationships reflect an accurate and executable path forward.

Programs should tailor the schedule-related items reviewed (including report format and level) in management reviews to match program management needs. Additionally, programs should regularly assess if the included schedules are adding value and adjust accordingly.

Things to Avoid

The Program Schedule Review should not just focus on the past; e.g. looking in the rear-view mirror and reacting. There should be consistent analysis and evaluation of status on the IMS forecast - because tasks do not always occur as planned.

Ensure the program schedule review is not just a presentation. The review is a time for all teams to reinforce effective management behaviors and communicate issues and concerns. It is an ideal opportunity to determine how the teams will work together towards achieving program objectives.

Related Topics

Intro to Schedule Execution Metrics
Managing using the IMS

12 Training

This section contains the following chapters.

12.1 Leadership Training

Manager's View

The success of a program is dependent on the leadership team's ability to understand and interpret the data contained in the IMS and to use the information proactively to drive the program to a successful outcome. The leadership's training should be targeted at a level where they understand basic scheduling concepts and can interpret the metrics to assess the health of the program's schedule, make decisions to impact the outcome and facilitate communication to their management and customers. Additionally, leadership training should occur in a timely fashion for program stakeholders, ideally prior to the start of their support to the program.

The central theme of all leadership training should be around the use of the IMS as a management tool versus simply a reporting vehicle. This theme should also emphasize the correct and incorrect management behaviors around schedule related metrics (i.e. manage by metrics v. letting metrics manage you). Finally, it is essential for management tiers to be proficient in the basic schedule "language" to increase the manager's effectiveness and ability to assist in breaking down program barriers for all program stakeholders.

Description

A comprehensive leadership training program should consist of a tiered approached based on the following roles: Senior Executive Leaders, Program Managers and CAM/IPT Leads. Training should aligned with the hierarchy of the IMS with CAMs/IPTs focused on the detail tasking, Program Managers focused on the program outlook, and Executive Leadership focused on the ability to manage goals.

Senior Executive Leadership training should define knowledge management practices that emphasize lessons learned and polices which ensure compliance with established regulations and the enterprise system description and procedures. The training program would continually evolve in the usage of metrics and toolsets which provide visibility into areas which are high risk to the execution of Program commitments.

The training for Senior Executive Leadership would include the following skills:

- High level overview of regulations and the system description especially as it relates to baseline establishment and change management
- Overview of schedule analysis and metrics (with a focus on how to use these metrics to make programmatic decisions and influence behavior) including:
    - CPLI, BEI, SPI, Duration-Based v. Scope-Based Percent Complete, Schedule Rate Chart, CEI, Critical Path Method and Analysis, Schedule Risk and Opportunities Assessment, and standard Schedule Health Assessment Metrics

Program Manager training would include management practices that emphasize proficiency in contract requirements and guidelines for architecting an IMS which will be an effective management tool for internal and external customers. The concepts of managing schedule margin and using critical and driving paths to make effective program decisions are emphasized. Decisions are made in a proactive manner utilizing the IMS as a tool which models the program's execution to requirements.

In addition to the skills listed under Senior Executive Leadership, the following skills should be included in the training for Program Managers:

- Overview of horizontal and Vertical Integration and Traceability (including the IMS relationship with the IMP)

- Overview of schedule health indicators
- Overview of the schedule validation and baseline process
- Overview of the schedule maintenance, status (including Time Now), and analysis battle rhythm
- Overview of how to use the IMS and its associated metrics and reports to manage the program (with, including but not limited to: float, critical/driving path analysis, and schedule margin)

CAM/IPT Leads training defines management practices that emphasize proficiency in contract requirements and guidelines for developing an IMS that will be an effective management tool to communicate execution to baseline requirements. The concepts of establishing activities, which provide the appropriate level of visibility into Key Program Milestones and accurate precedence logic amongst teams along with an understanding of managing with float and critical path, allow the use of the IMS as a forward-looking tool for execution of requirements. Management of subcontractor efforts is a key attribute in this training module in order to ensure the proper integration of supplier efforts within the Program IMS. Emphasis on metrics for managing the Program such as Trip Wire metrics are essential in order to be effective in communicating with the IMS.

In addition to the skills listed under Senior Executive Leadership and Program Managers, the following skills should be included in the training for CAMs and IPT Leads:

- An in-depth understanding of how the scheduling tool works
- An in-depth understanding of the schedule baseline maintenance, status, and analysis processes

Things to Promote

Learning through knowledge sharing and mentoring.

Certification training tailored to level of leadership within the program team.

Using tools to foster positive behavior for program execution.

Leadership Training Program with Learning Objectives from Executive to Practitioner, in a forum tailored to the desired competency. Method of delivery is flexible to target audience, with material from Subject Matter Experts from cross-functional departments.

Invite program, customers, and DCMA representatives to the IMS-related leadership training sessions.

Manage using metrics versus letting metrics manage you.

Things to Avoid

Learning environment dependent on internal political factors.

Poorly defined Learning Objectives.

Inflexible method of delivery.

Leadership Training Program that does not have a well-defined learning model for Executive Associates through Entry Level Associates.

Over-reliance on knowledge sharing and mentoring, without regular training on baselined best practices.

Related Topics

Planner/Scheduler Skills and Training
Managing using the IMS

12.2 Planner/Scheduler Skills and Training

Manager's View

The ability to manage the information within the IMS is dependent on a combination of skill sets and knowledge necessary to develop, interpret and analyze the data. A planner/scheduler's training must be broad enough to communicate effectively with the program team, drive the planning process to ensure the IMS reflects how the work is accomplished and provide data in a form that will aid the team in making sound management decisions. Ensure Planner/Schedulers have sufficient knowledge, training, and understanding of the scheduling discipline prior to the start of their support to a program.

A robust training program will identify the learning objectives that best support development of these kinds of skill sets and knowledge combined with program requirements.

Description

Roles and responsibilities

The role of an effective Planner/Scheduler on a program is multifaceted. Their role includes leading the team in the use of sound scheduling practices; ensuring program processes align with Enterprise guidelines or Systems descriptions and actively participates as a valued member of the program leadership team. Understanding the qualities that enable a Planner/Scheduler to make the most of these roles will greatly influence the type of training to support each.

Use of sound scheduling practices

The Planner/Scheduler plays a significant role in the use of sound scheduling practices. Examples include the development of a logically linked network to allow accurate critical path analysis based on network calculations/logic, validation of staffing load with a resource loaded schedule, and regular review of program data by the core program team to assess accuracy and feasibility and promote team buy-in.

Aligning to Enterprise EVMS or Program Planning Guidelines

Work done in support of government contracts typically requires a validated EVMS system. Additionally, internal policies and procedures define requirements for managing cost and schedule. Planner/Schedulers should be knowledgeable on all policies and procedures that affect the IMS and be able to translate and apply these requirements on the programs, they support.

Valued member of program leadership team

The Planner/Scheduler is an important member of the program leadership team. Providing detailed analysis of the IMS associated with each update, processing change request with documented visibility into the change, or award of additional scope, the Planner/Scheduler is the subject matter expert to focus the team on the areas impacted and needing additional review. As most people are visual learners, the Planner/Scheduler should understand when additional training is required to interpret the data or be creative in developing a different format for the data.

Skills for Execution

The most effective Planner/Schedulers possess a balance of intellectual qualities or assets that include the possession of the knowledge, applied experience, organizational technology, customer relationship and professional skills. These assets are often grouped into categories referred to as Soft and Hard Skills.

Soft skills

Soft skills, sometimes known as "people skills," are personal attributes that enhance a Planner/Scheduler's interaction, job performance and even career prospects and are defined as a wide variety of business skills that fall into one of the following three categories:

1. Interaction with Coworkers - This category is the ability to interact effectively with coworkers and customers and includes skills such as networking, communication, and teamwork/collaboration.
2. Professionalism and/or Work Ethic – This category focuses on how a person conducts himself or herself at work and includes skills of professionalism, integrity, enthusiasm/motivation.
3. Critical Thinking or Problem Solving – This category deals with one's ability to think about and evaluate problems objectively and solve them in a reasonable timeframe.

Hard skills

Hard skills are those easily observed and can be taught in a formal classroom setting or using an on-the-job situation. For Planner/Schedulers, examples of hard skills include the ability to work with scheduling software or associated add-on software, work with spreadsheets, integrating and analyzing IMS data with other functional areas such as finance or risk and opportunity or even include learning and speaking a foreign language.

Types of training

Training is not limited to classroom instruction and can take many forms.

Examples of alternative forms of training include on-the-job training, internal or external training courses, mentoring, training assignments, role-playing or peer review exercises.

Example

Soft skills training examples include:

- Effective communication
- Leading a team
- Conducting a meeting
- Problem Solving
- Working with difficult employees
- Presentation skills

Hard skills training examples include:

- Tool specific training such as MS Project, Primavera, Open Plan, etc.
- Working with Microsoft Office products (Excel, PowerPoint, Word)
- Fundamentals of Planning
- Cost/Schedule Integration
- Schedule Analysis
- Critical Path Analysis
- Schedule Risk Analysis
- Metric Analysis – such as BEI, CPLI, SPI, etc.
- Subcontractors schedule integration
- Managing Risk and Opportunity in the IMS

Optional Techniques

Boot Camps

Train-the-trainer (TTT)

Mentoring

Peer Reviews

Things to Avoid

A training plan that only utilizes one method for training such as Web Based Training.

Vague Learning objectives.

Related Topics

Leadership Training
Managing using the IMS

13 Program and Contract Phase Considerations

This section contains the following chapters.

13.1 Proposal IMS Considerations

Manager's View

In general, programs benefit from developing and refining their program IMS as early as possible. In many cases, this means constructing a comprehensive IMS to support a proposal submittal. While there is not a fundamental difference between an execution and proposal IMS, there are some unique items to consider when developing a proposal IMS. This section defines those considerations.

Description

Consider the following regarding the building of a Proposal IMS:

- Proposal team goals should be to create an IMS with health standards as close to the execution criteria as possible.
- Proposal schedules are typically not "earned value" ready as the control accounts may not have been established.
- Resource loading proposal schedules may be required and/or may be at a higher level, which supports the reconciliation between the IMS and the BOEs.
- Ensure consistent IMS structures (i.e. IMP/WBS) between the proposal and execution IMS. This greatly simplifies the transition from a proposal to an execution IMS.
- The IMS may be less detailed in the proposal than in execution. This allows the execution CAMs to develop the specific execution details.
- IMS Supplemental Guidance document should be included with the IMS submittal to explain approaches, ground rules, and assumptions used in the development of the proposal.
- IMS Specific RFP requirements (i.e. restrictions on the # of tasks in the proposal IMS) may not afford for the creation of a proposal IMS consistent with execution IMS standards.

Related Topics

Managing using the IMS
Scheduling in a Production Environment

13.2 Scheduling in a Production Environment

Manager's View

The Department of Defense (DoD) 5000.02 Instruction identifies the following program phases:

1. Material Solution Analysis Phase
2. Technology Maturation & Risk Reduction (TMRR) Phase
3. Engineering and Development (EMD) Phase
4. Production and Deployment Phase
5. Operations and Support Phase

During Production, a contractor or organization produces/provides physical products that are typically the result of efforts from the development phase of a contract. While the development and production phases of an acquisition are closely related, the means of managing schedules can be very different. During development, an Integrated Master Schedule (IMS) is normally required, developed, and maintained. In production, the judicious application of an Integrated Master Schedule (IMS) can in some cases be used to complement and supplement existing production-planning processes. This is because using an IMS during production can be helpful in tracking and monitoring high-risk items.

Note: The use of an IMS is often not applicable on Full Rate Production (FRP) programs.

Description

A production system is a framework of activities within which the creation of value can occur. At one end of the system are the inputs; at the other end are outputs. Connecting the inputs and outputs is a series of operations or processes. Although all production systems differ somewhat, there are two basic types; one is based upon continuous production of a product, and the other is based upon intermittent production of a product.

Most production-schedule architecture discussions and decisions focus on the relationship and integration of Manufacturing Resource Planning (MRP II) data with an Integrated Master Schedule (IMS). The goal should be to balance the value-added summarization of MRP tasks in the IMS as representations of the detailed manufacturing activities for managerial visibility and assessing meaningful critical path impacts. To understand these decisions, a consistent understanding of the following processes is necessary:

1. Integrated Master Plan (IMP)
2. Material Requirements Planning (MRP)
3. Master Production Schedule (MPS)
4. Manufacturing Resource Planning (MRP II)
5. Line of Balance (LOB) Technique
6. Integrated Master Schedule (IMS)

1. Integrated Master Plan (IMP) is an event-based plan consisting of a hierarchy of Program Events, Significant Accomplishments, and Accomplish Criteria. An IMP is usually required for development programs and may be required for Low Rate Initial Production (LRIP) but is rarely required for Full Rate Production programs (FRP).

2. Material Requirements Planning (MRP) is a high-level production planning and inventory control system used to manage manufacturing processes. It ensures materials are available for production, and that products are available for delivery to customers. MRP employs backward (As Late As Possible) scheduling using the customer need date (i.e. independent demand) to determine setbacks. MRP uses quantities; product structure, also known as the Bill of Material (BOM); current inventory levels; and supplier and manufacturing lead times, to determine when material acquisition, fabrication, assembly and test activities must begin to ensure an organization meets its delivery date(s).

Independent demand is typically a customer defined requirement documented in the contract.

MRP balances:

1. Demand
    a. What do I need?
    b. How many do I need?
    c. When do I need it?
2. Supply
    a. What to buy/make?
    b. When will it arrive?
    c. How many will be delivered?

Any delay to start and finish dates calculated by As Late as Possible (ALAP) scheduling, causes the need for expediting and/or workarounds. Because MRP employs ALAP scheduling, it is prudent to work toward internal delivery dates that are prior to these contractual delivery dates. Use of a setback schedule allows time to resolve future unforeseen production problems.

Production Systems assume lead times are the same each time an item processed through the factory (regardless of quantity, capacity, and potential learning curves). MRP results may therefore be impossible to implement or execute to due to labor, machine, and/or supplier capacity constraints.

3. Master Production Schedule (MPS) is the anticipated build schedule for each product on the line. It translates the business plan (including forecast demand), into a production plan using planned orders. A master production scheduler develops an MPS that makes it possible, given resources available to the company, to meet business plan requirements/demands. The MPS takes the form of items, quantities, and specific dates. Unlike the business plan, the MPS level of planning is within the context of individual product family members instead of the broad context of product families.

4. Manufacturing Resource Planning (MRP II) systems expand upon MRP. MRP II brings integrated financials, MPS, rough-cut capacity planning, and capacity requirements planning to MRP. It facilitates the development of a detailed production schedule that accounts for machine and labor capacity, and schedules production runs according to the arrival of materials. The MPS is a key ingredient in the evolution of MRP to MRP II. Fluctuations in forecast data are taken into account by including simulations of the MPS, also referred to as Rough-Cut Capacity Planning (RCCP), thus creating medium to long-range (i.e., 1 – 5 years) control. Use RCCP to test proposed changes to the MPS. Capacity requirements planning (including infinite capacity planning), and finite capacity scheduling (including operations sequencing), provide short-range (i.e., months, weeks and days) control down to the workstation level. Shop floor control systems (in conjunction with MRP II) schedule finishing or final assembly work on the factory floor via a daily dispatch list. State the Detailed factory-floor work–schedules in terms of hours and minutes. A key MRP II output is a final labor and machine schedule.

5. Line of Balance (LOB) Technique

LOB is a management technique for collecting, measuring and presenting facts related to time, cost and accomplishment – all measured against a specific plan. It shows the process, status, background, timing and phasing of the project activities, thus providing management with measuring tools that help:

1. Comparing actual progress to a formal objective plan

2. Examine only the deviations from established plans and gauge their degree of severity with respect to the remainder of the project.
3. Receiving timely information concerning trouble areas and indicating areas where appropriate corrective action is required.
4. Forecasting future performance

The "Line of Balance" (LOB) is a graphical device that enables a manager to see at a single glance which of many activities comprising a complex operation are "in balance" (i.e. whether those that should have been completed at the time of the review actually are completed and whether any activities scheduled for future completion are lagging behind schedule). The Line of Balance chart comprises only one feature of the whole philosophy, which includes numerous danger signal controls for all the various levels of management concerned.

6. Integrated Master Schedule (IMS) - Per Integrated Master Schedule (IMS) Data Item Description DI-MGMT-81650 and the IPMR DID, an IMS is an integrated schedule containing the networked, detailed tasks necessary to ensure successful program execution. The IMS is vertically traceable to the Integrated Master Plan (IMP) (if applicable), the Contract Work Breakdown Structure (CWBS), and the Statement of Work (SOW). Use the IMS to verify attainability of contract objectives, to evaluate progress toward meeting program objectives, and to integrate the program schedule activities with all related components. Per DI-MGMT-81650 and the IPMR DID, the IMS is applicable to development, major modification, and low rate initial production efforts; and is typically not applied to Full Rate Production (FRP) efforts.

Base the need for an IMS on contract value, contract-type, volatility of design, capability of existing production systems, and project management needs. As a program-approved process, any IMS should be developed and maintained to complement and supplement (instead of replacing or duplicating) existing design/production systems and processes. An IMS based on a logical network of interdependent tasks allows critical path/float analyses and identifies Hand-offs between and among performing organizations. A production IMS should contain schedule-significant activity strings and draw upon the strengths of existing production systems (such as MRP/MRP II), and applicable performance measurement systems (such as Earned Value).

Why Use an IMS During Production?

MRP II / LOB can provide exception reporting to the labor/machine schedules. The use of an IMS in conjunction with existing production systems allows for on-going critical path/float analyses, what-if analysis, external dependencies on items outside the MRP systems (i.e. software loads, engineering change/development activities, etc.) and the addition of resource attributes allows for the determination and reconciliation of cost and schedule variances. Perform Critical Path/float analyses throughout the period of performance of a contract to ensure adequate resources are available for critical/near-critical program activities.

Always utilize an IMS during the transition from development to production and more specifically during any Low Rate Initial Production (LRIP) contract. During Full Rate Production (FRP), the benefit of using an IMS should exceed the effort of its development and maintenance. Enhance IMS fidelity by early development and tailoring based upon the availability/maturity of related supporting production/management systems and processes.

Use of a logically networked IMS that is effectively and efficiently integrated with existing production systems, can be used to determine performance criticality and status; perform critical path analysis, "what if" exercises and SRAs; and identify lurking risks and potential opportunities.

Risks

The nature and maturity of a program drives the quantity and type of risks and opportunities. However, keep in mind that the risk focus is different between development and production programs. Development programs are more concerned with design and development, and production programs are more concerned with parts availability, produce ability engineering, and obsolescence. LRIP programs utilize a small production lot to transition from the completion of the development phase to the Full Rate Production Decision Review.

Production IMS Content/Considerations

Scheduling in a production environment is similar to scheduling in a development environment in that program maturity drives variation to IMS volatility, fidelity, and health metrics. During development, there is a greater emphasis on the identification of program/system requirements, and the prove-out of design concepts. During production, emphasis changes from non-recurring design/development activities, to recurring fabrication and test activities.

As a program approved process, the decision to employ an IMS should be based on whether it will compliment and supplement existing design/production systems and processes. An IMS should be modeled, generated, and maintained to interact/interface with related production/management system/processes associated with material acquisition and control, inventory management, and shop floor processes.

Due to the nature of a development program, IMS activities, linkages and resources are not as tangible or certain as during a production program. For either type of program, one should develop and model an IMS that provides a reasonable and measurable means to execute the program. The IMS needs to accurately represent key program activity chains and avoid replicating all the details that are already contained in supporting systems.

Material

Most production builds require the purchase and receipt of major/minor equipment and common piece parts. Normally, a factory would generate a subcontract for major components and assemblies/subassemblies above the production or technical capabilities of the factory. Procure Off-the-shelf piece parts, also known as General Purchase (GP) items, in bulk.

General Purchase Items - Procuring items in bulk generally yields a lower per-unit price. A number of factors determine the size of a lot-buy including: design stability, contractual quantities, budget availability, and unit cost. Model the IMS to allow for interim and/or out-of-sequence deliveries.

Most production builds require the acquisition, handling, and assembly of hundreds of unique piece parts. Most purchasing/production systems do an excellent job of identifying hardware requirements and tracking the purchase and receipt of each of these items.

Because each of these hundreds of GP items is inherent within the IMS, discrete IMS activities should only be created for schedule-significant or fixture-critical items (those items that preclude an assembly from entering or exiting the next phase of production). There are at least three (3) ways to model the IMS to include schedule-significant GP items:

1. Interface hand-off milestones that represent purchase order issue dates and/or delivery dates
2. Zero-duration milestones (that represent purchase order issue dates/delivery dates) connected by lags or Schedule Visibility Tasks (SVT)
3. Schedule Visibility Tasks (SVT) that represent lead times.

Of the three, the third option is the easiest to implement since it provides an easy means to depict completed and remaining supplier work. Depending on company EVMS procedures, these activities may or may not be designated as Work Packages or defined as Schedule Visibility Tasks (SVT)

Major Subcontracts

Most production builds require the acquisition, handling, and assembly of dozens of subcontractor-supplied sub-assembles/assemblies. Most purchasing/production systems do an excellent job of identifying major hardware requirements and tracking the purchase and receipt of each of these items.

Because most major hardware requirements are schedule-significant, each of these items should be included and linked within an IMS. There are at least four (4) ways to model the IMS to include schedule-significant major hardware requirement items:

1. Interface hand-off milestones that represent purchase order issue dates and/or delivery dates.
2. Zero-duration milestones (that represent purchase order issue dates/delivery dates) connected by lags or activities.
3. Schedule Visibility Tasks (SVTs) that represent lead times. This option is the easiest to implement since it provides an easy means to depict completed and remaining supplier work.
4. Fully integrate the subcontractor's schedule into the Prime IMS.

Shop Floor Processes

Because the IMS and shop floor processes should work hand-in-hand, the integration of the two needs to consider the strengths and weaknesses of each of the systems. Take care to keep these systems in sync throughout program execution.

When used properly, MRP / MRP II databases reflect all the documents, parts, processes, and resources that yield a production deliverable. Most MRP systems use just-in-time scheduling and/or setbacks to identify need dates. Managers in turn create internal schedules and assign resources to meet or beat these need dates. A good IMS converts backward-looking MRP data into forward-looking IMS data. The creation of an activity interdependency network allows the determination of critical items, free/total float, and schedule risk based on three (3) point estimates (minimum, most- likely, and maximum remaining durations).

Use Cycle times to smooth resources by minimizing downtime. By stacking and then offsetting stages of production, a product can readily move from one crew/fixture to another. Early or late completion of a cycle adversely effects the smoothing of resources. By assuring the completion of fixture-critical items on time and in-station, non-fixture-critical activities items may in turn be delayed or done-out-of-station on a non-interference basis.

When it is not possible or practical to complete a cycle on time, non-fixture dependent tasks are often delayed and done out of station. Doing this work out-of-sequence (on a non-interference basis) is usually more economical than violating standard cycle times and causing choke points. Standard cycle times therefore usually include some wiggle-room to allow for inevitable unforeseen workarounds.

Take into consideration contractor/subcontractor work calendars when scheduling a program. Instead of overwriting pre-defined contractor/subcontractor work calendars, use calendar days/alternate resource calendars to schedule tasks that fall on working days. (Reference the Working Calendars chapter in the guide).

Other Production Considerations

As required, production programs should address related items such as: NRE (Non-Recurring Engineering), rework and scrap, Obsolescence, resource requirements and availability, touch/support labor, standard/budgeted hours, and external dependencies.

Update the IMS to reflect the integrated path forward due to recovery and work-around plans on the production floor. This includes adjusting for traveled work.

Correlate IMS tasking to production system details. Production Program activity durations are often longer than development program activities due to the numbers of long supplier lead times. Production IMS tasks should represent key project activity chains. IMS tasks should not be arbitrarily broken up to hit metrics guidelines.

Optional Techniques

Load-Leveling Technique: Every plant manager's dream is to run the manufacturing facility at a steady pace – i.e., at a level load. The plant loads vary widely; there is underutilized capacity during some periods, and the need for costly overtime in others. These fluctuations are due to fluctuating demand, equipment downtime, and/or poor scheduling. Master Production Schedulers attempt to even out production peaks and valleys. Building-up stock (and incurring excess inventory costs) is one possible solution. Working with the sales department to manage demand is another possible solution. Discounts could be effective in this effort. Breaking the overall time span into smaller blocks, and level loading these blocks is another solution.

Things to Promote

As a minimum, review production schedule artifacts weekly in support of at least a monthly IMS status process.

Develop guidelines or "rescheduling time zone rules" to aid master production schedulers in making decisions. Management policies drive the rules that specify the kinds of changes allowed to the production flow at certain points in time. For the sake of discussion, say that;

- Zone A includes the current and near-term periods and is one in which the master production scheduler and management should carefully investigate all suggested changes. Changes here will be disruptive and costly. Consider implementing only safety and emergency changes here.
- Zone B is one in which caution should be exercised with respect to changes. Capacity and material availability for changes need scrutiny here, and the prioritization of different orders may be required. The boundary between Zone A and Zone B often coincides with final assembly.
- Zone C, the master scheduler is free to make changes as long as the schedule remains within the production plan constraints. This period is far enough into the future that the master scheduler can modify the IMS without affecting the procurement of material or the process of getting the product to market. The boundary between Zone B and Zone C is typically the cumulative lead-time to build the production article.

Integrate and drive engineering and production activities with a common production scheduling system.

Things to Avoid

Do not permit the production steps to go past due and remain there.

Capacity planning and MRP II are tools that may support proposal inputs. However, to validate these recommendations, a full complement of planning tools is necessary. The Master Production Scheduler will adjust the production line whenever an unbalanced supply and demand condition exists or when policy violations occur.

Related Topics

Resources in the Schedule
Working Calendars
Schedule Visibility Tasks (SVT)

13.3 Scheduling in an Agile Environment

Manager's View

Agile has emerged as the leading industry software development methodology and has seen growing adoption across the DoD and other federal agencies. Modeling Agile behavior in the IMS can be a paradigm shift for the planner/scheduler. This is because of Agile's iterative approach to performing work. The incremental nature of development coupled with the emphasis on features may require longer tasks and interrogation of CAMs as to the meaning of tasks. Critical and driving paths must be valid and depict the software development connection to downstream deliverables for the entire program. Although successive Release content is not detailed initially, modeling of Agile effort in the IMS must adhere to baseline management. Additional disciplines such as Systems and Firmware may also participate in Agile behavior on a program. The planner/scheduler must remain vigilant for significant inter-CAM hand-offs that need to be represented in the IMS under construction. Agile behavior on a program will impact the WBS, schedule structure, derivation of earned value, and timing of planning.

Description

The Agile process has concurrent team collaboration. Integration starts early and continues throughout development. The idea is to "build a little, test a little". See figure 14-1 below. This method offers early risk mitigation and a limitation to defects escaping to the customer. This is in contrast to the traditional "Waterfall" process where the entire functionality goes through each part of the program lifecycle together in serial fashion. Waterfall has the potential to delay the team's discovery of issues until late in the program which may introduce additional risk.

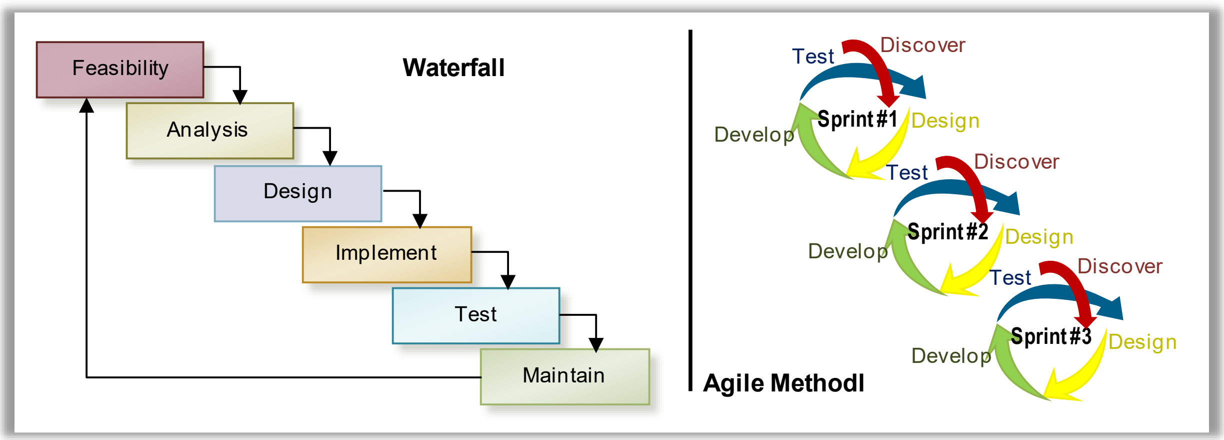


Figure 13.3-1 Waterfall v Agile Modelling

Prerequisites

The planner/scheduler should ascertain that planning prerequisites specific to modeling Agile behavior on a program have been met:

1. Team has a working knowledge of Agile techniques and concepts
2. Initial Product Backlog and Roadmap is in place
3. An Agile toolset that can map/trace to the IMS is in place
4. Agile Team has received training on Agile (onboarding)
5. A product oriented WBS aligned with business outcomes at the highest summary levels.

Hierarchy

For Agile work packages, tasks become feature-centric in the IMS. Task names that characterize the features should be created as succinctly and unique as possible. Each feature-based task should be tied as a predecessor to other tasks representing features that are dependent upon its completion. Features may be longer in duration compared to programs not using the Agile methodology; this is suitable if the task reflects the work, possesses accurate network logic, and is backed up by Agile-based QBD.

Stories are elements of Agile that implement the Features in an IMS. Stories exist at a lower level than Features. Stories are housed and tracked in an Agile management tool that is separate from the IMS. Stories are assigned to Sprints in the Agile management tool and are vertically traceable to the Features in the IMS through coding fields like WBS, Control Account Number, and Work Package Number. Because stories are more detailed, they are not modelled in the IMS. Figure 14-2 shows a hierarchy of Agile Products above and below that which would be modeled in the IMS – features and capabilities. The figure also contrasts the product, which is based on the WBS and would eventually be broken down into IMS tasks v. the cadence or rhythm, which is time-based and should not be modeled in the IMS

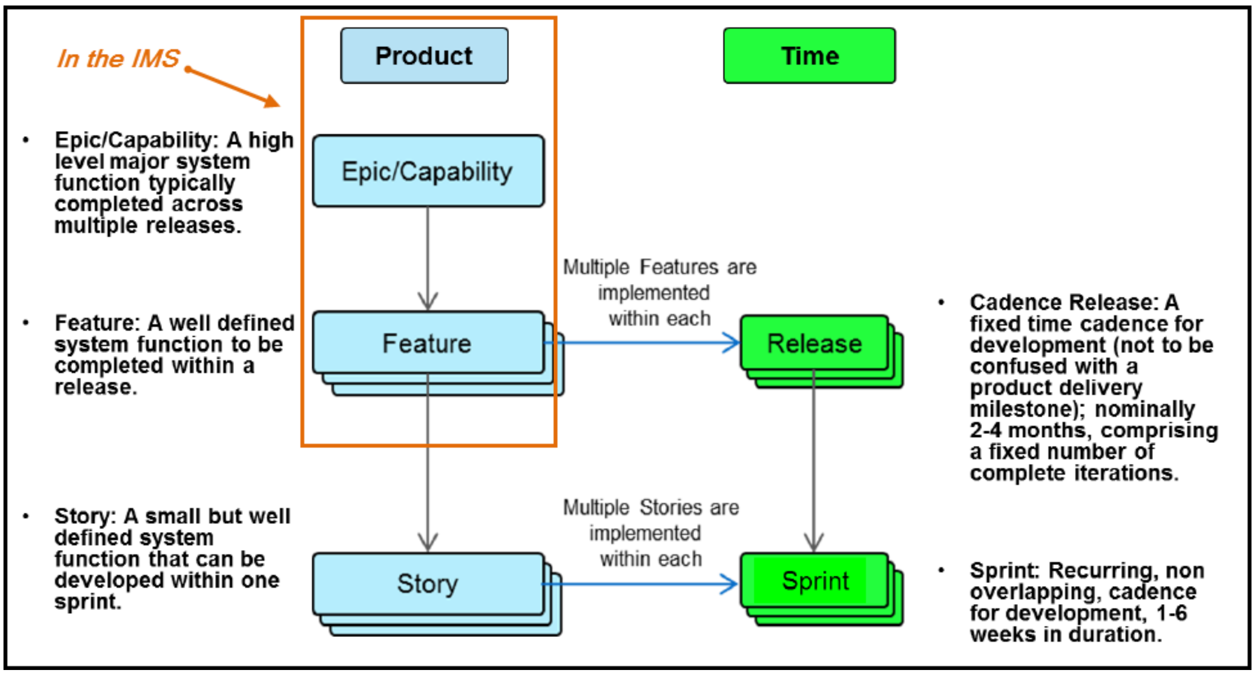


Figure 13.3-2: Agile specific modelling attributes

Application

At program start, an initial Product Roadmap with work product functionality will be created showing a plan for Epic/Capability and Feature development across the Cadence Releases, considering architectural and product dependencies as well as customer milestones. The IMS content, Features and their associated start/end dates and dependencies, will be finalized through Rolling Wave planning, prior to the start of the execution of the associated Cadence Release. Figure 14-3 shows a Rolling Wave Planning process in the IMS with Cadence Release 1 planned, while content for the next Cadence Releases still contained in Planning Packages remains to be refined in subsequent Rolling Waves.

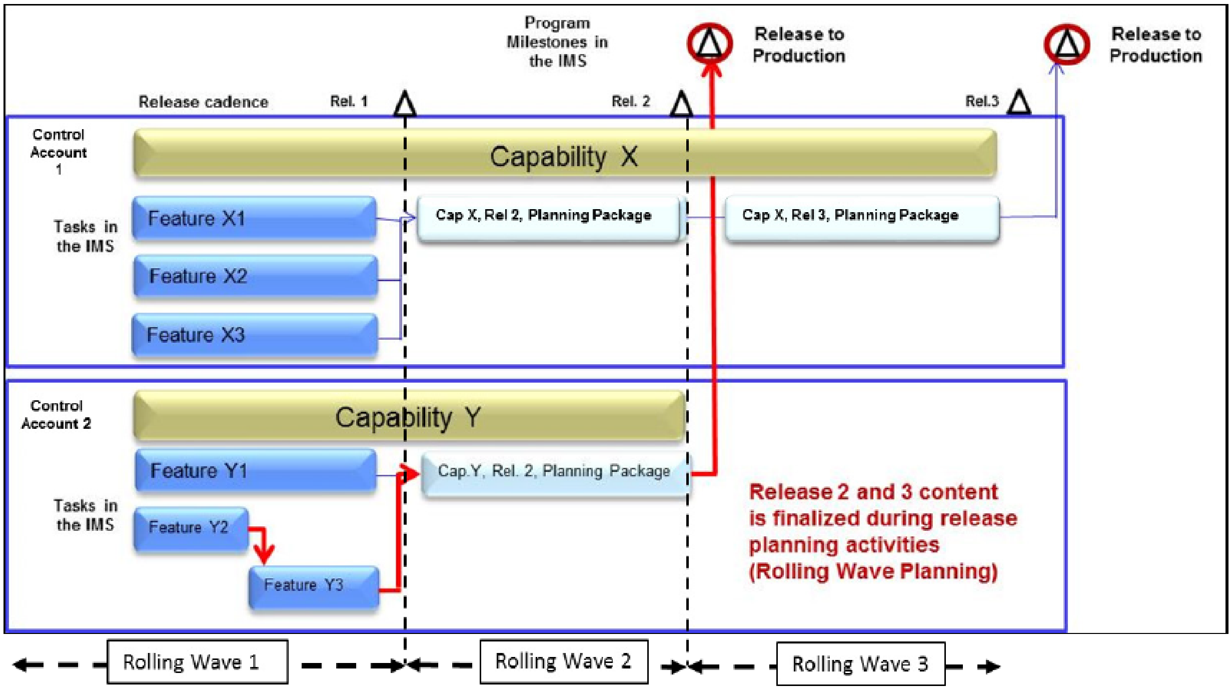


Figure 13.3-3: Modelling Rolling Waves in Agile

Examples

Example IMS tasks and subtasks are shown in figure 14-4. These correspond to Control Accounts and Work Packages. Work Packages align with a single Feature or group of related Features. It shows part of a program with Cadence Releases of 85 working days. Two Epic/Capabilities are developed, each requiring three Features that would each trace to a Work Package, plus Planning Packages assigned to future Cadence Releases. The Cadence Release milestone is a fixed date as it is time-boxed and has no defined dependencies with the product IMS tasks.

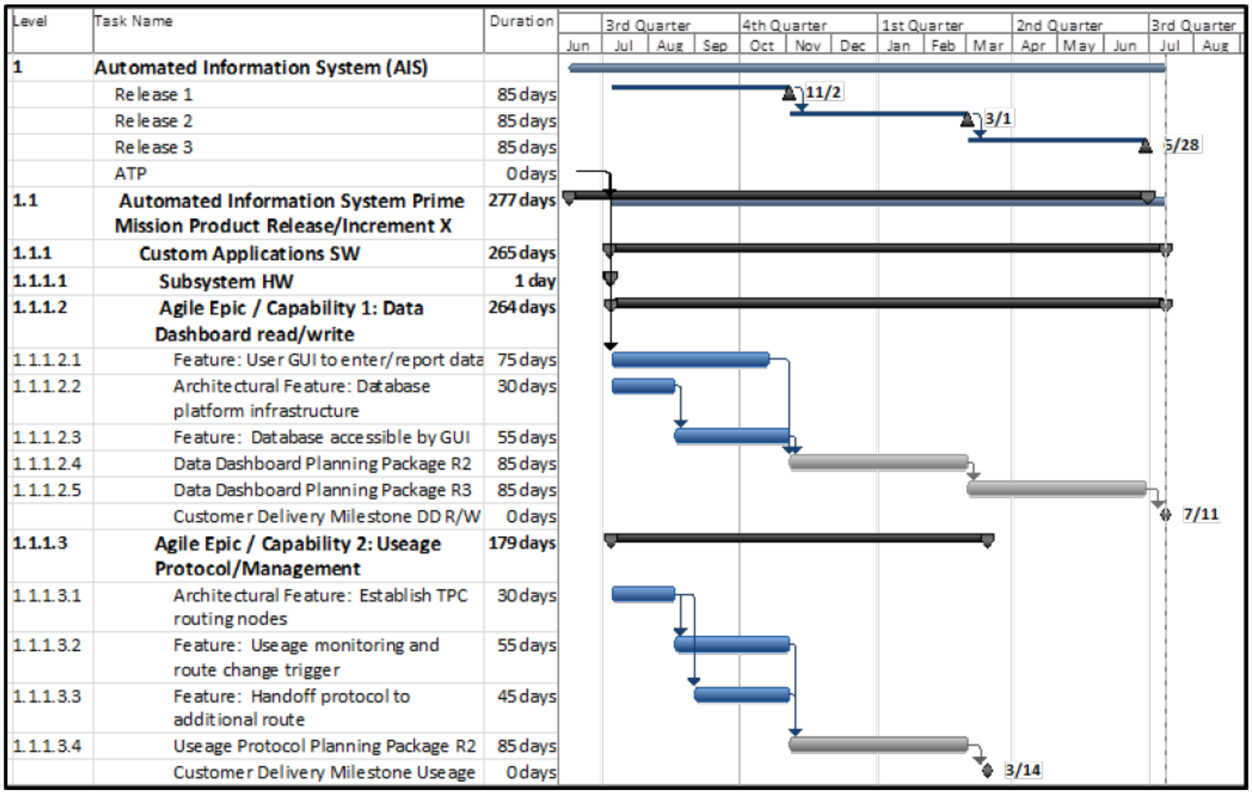


Figure 13.3-4: Example Agile Modelled IMS

IMS considerations drawing from the IMS example in Figure 13.3-4:

- Network logic between Work Packages shows dependencies across product Features. In Figure 14-4, level 1.1.1.2.2 for "Architectural Feature: Database platform infrastructure" must complete before level 1.1.1.2.3 "Feature: Database accessible by GUI" can be started. The IMS may include other dependencies such as test equipment, power supplies, hardware, or simulation software, as well as dependencies between the to-be-developed products (not shown in this figure). The cross-functional Agile teams should minimize dependencies/handoffs between teams based on disciplines (e.g., systems engineering, development, and test). To the extent that product level dependencies still exist, they must be modeled in the IMS to establish a critical path.
- The IMS is baselined prior to any work for the Cadence Release content being started. Release Planning in the IMS defines where the IMS is synced with the Agile plan, prior to execution of the work.
- IMS status is informed by progress from the Agile management tool via burnup or burn-down reports and Agile-based QBDs.
- In the IMS, work or planning package tasks are permitted to span the duration of a Release given there are no significant inter-CAM handoffs or major Feature-to-Feature dependencies existing within the Release

Things to Promote

Features are desired to be the lowest level in the IMS.

Link dependencies in the IMS between Features to understand driving/critical path to customer delivery.

Align Rolling Wave planning with the Agile Program Increment (PI) planning.

Decouple Customer Release/Delivery from a Program Increment Release; only represent Customer Release/Delivery in IMS.

Things to Avoid

Do not model Sprints or increments in the IMS – these are "time-boxes".

Do not model Stories in the IMS – the Agile management tool houses and tracks this lower-level data

Related Topics

Critical and Driving Path Analysis
Baseline Maintenance

Related Reading

An Industry Practice Guide for Agile on Earned Value Management Programs (NDIA)

Agile and Earned Value Management: A Program Manager's Desk Guide (PARCA)

13.4 Scheduling in a Construction Environment

Manager's View

For Construction projects, the following are the typical phases of the project lifecycle:

- Design Phase
- Construction Contract Procurement Phase
- Engineering Submittals Phase
- Procurement of Material and Equipment Phase
- Construction (Installation) Phase
- Startup and Commissioning Phase
- Turnover to Operations Phase

During Construction, a contractor or organization builds/produces physical products that are typically the result of the design phase of a project. The design is a process of creating the description of a new facility, usually represented by detailed plans and specifications; construction planning is a process of identifying activities and resources required to make the design a physical reality.

For a construction project, all phases of the life cycle and work scope associated with the project are contained within a single Integrated Master Schedule (IMS). The IMS is the management tool that communicates what work will be performed, which resource of the organization will perform the work and the timeframes in which that work will be performed. It is essential that the IMS is organized in a hierarchy that is horizontally integrated within a critical path method (CPM) network and vertically integrated with critical subcontract work scope and other lower level schedules as a means to delivering the project on time.

Note: The use of a resource loaded IMS is always applicable for the Design and Construction process.

Description

Critical Path Method (CPM) Scheduling

The critical path method considers the logical dependencies between work scope elements and considers the resource requirements related to each task. A resource-leveled schedule looks to address potential delays due to resource bottlenecks (i.e., unavailability of a resource at the required time), and may cause a previously shorter path to become the longest or most "resource critical" path. The network links all project milestones, events, and tasks in logical cause and effect sequences to determine the required time and resources needed to complete individual work scope and more broadly the project. The critical path is the longest path of related incomplete tasks in the logic network from 'time-now' whose total duration determines the earliest project completion. A review of the calculated critical path reveals those tasks that are causing delays in accomplishing work scope and those tasks that jeopardize the project timeline. This analysis helps management focus on the issues to develop workaround plans and seize opportunities.

Lifecycle Planning

The lifecycle of a construction project commences from project initiation and conceptual design and completes with operating the facility. The entire scope is included in one single IMS that has the complete critical path from the start to completion.

As the entire scope is planned, it is common to utilize rolling wave concept to plan the early phases in more detailed, finite tasks and later phases in higher level tasks. As phases are nearing completion and the following phases are more defined, the higher-level tasks are defined and are detailed into finite tasks.

Resource Loading

Resource loading in a Construction Environment is essential as it provides information useful in decision-making by executives, program managers, and stakeholders. The resource information produces valuable information on the achievability of the plan from a resource demand v. availability as well as budgetary and funding analysis.

Often times, resource loading tasks in a Construction Environment will focus on labor resources, as resource availability is likely a primary constraint on the ability to perform tasks as planned. However, for effective resource planning, both labor (hours) and non-labor (units or Dollars) should be loaded, reviewed and analyzed.

The assignment of labor resources can be either the total effort in person-hours to accomplish the task or total hours as a result of production (installation) rates and the quantity of commodity material or equipment being installed. Either loading will derive a total person-hours by labor category (type) within each task. The more defined the type of resource (i.e. construction craft type such as pipefitter, carpenter, electrician, etc.), the better understanding of resource demand. Verifying resource demand and confirming the availability of each type of resource throughout the phases of a construction project is key in ensuring a viable and achievable plan.

Construction labor resources can also be loaded as a composite crew resource type. In several instances, a certain task necessitates a crew effort to execute the task (i.e. a concrete pour crew requires typical resources comprising carpenters, laborers, concrete finishers, and operators). In the case of loading composite crews as a resource type, the crew resource can be loaded in crew-hours or number of crews assigned to the task.

Resource profiles are generated, typically by resource type, based on resource loading and time phasing of each task. Resource profiles are histogram-type curves representing resource needs over time. Labor hours/quantities or non-labor units/dollars are shown on the Y-axis and timeline by period (day, week, month, quarter, etc.) on the X-axis.

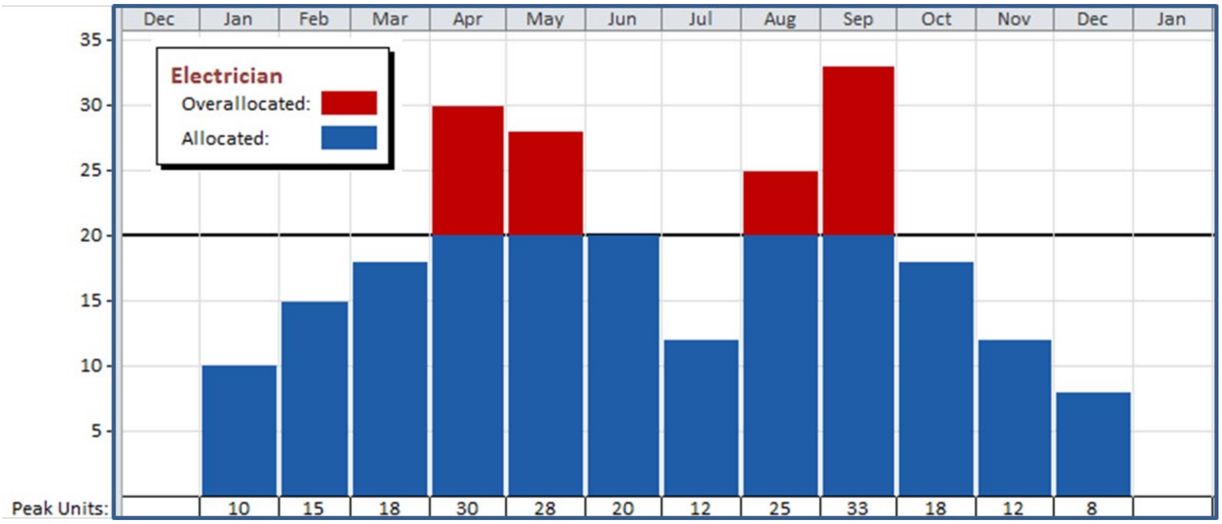


Figure 13.3-1 Example of Resource Histogram (prior to resource leveling)

Resource profiles are commonly used for evaluating resource demand v. availability in order to verify the achievability of the plan. Resource profiles are also used to examine the efficiency (leveling) of the plan. A resource-efficient plan typically eliminates sharp peaks and valleys between time periods and eliminates interruption (idle time) along the timeline of the resource utilization. An achievable plan shows the quantity of each resource type by period (day, or week) not exceeding the available crew. An efficient plan shows a relatively consistent number of resources planned continuously along the timeline.

Resource Leveling

As the IMS is planned with a complete logical sequence of execution and required resource loading for each task, resource profiles can now be generated for each type of resource. Oftentimes the initial resource profile of a project will show a plan that has resource utilization that is inefficient with resource demands exceeding availability during some time periods or with resource peaks/valleys, which indicate times of resource over or under utilization. Many scheduling tools can automate resource leveling calculations to derive an achievable resource-leveled plan, meeting resource availability with efficiency. Automated resource leveling can be used initially, and once the plan is resource-leveled, logical relationships between tasks with common resource types can be introduced to plan the sequence of execution. This is known as "crew-sequencing" as the relationships between tasks are resource-driven relationships that are based on resource availability and a certain predefined priority sequence. It is important to document these additional logical relationships as being "resource dependent" so as not to confuse them with relationships describing the physical sequence of required work.

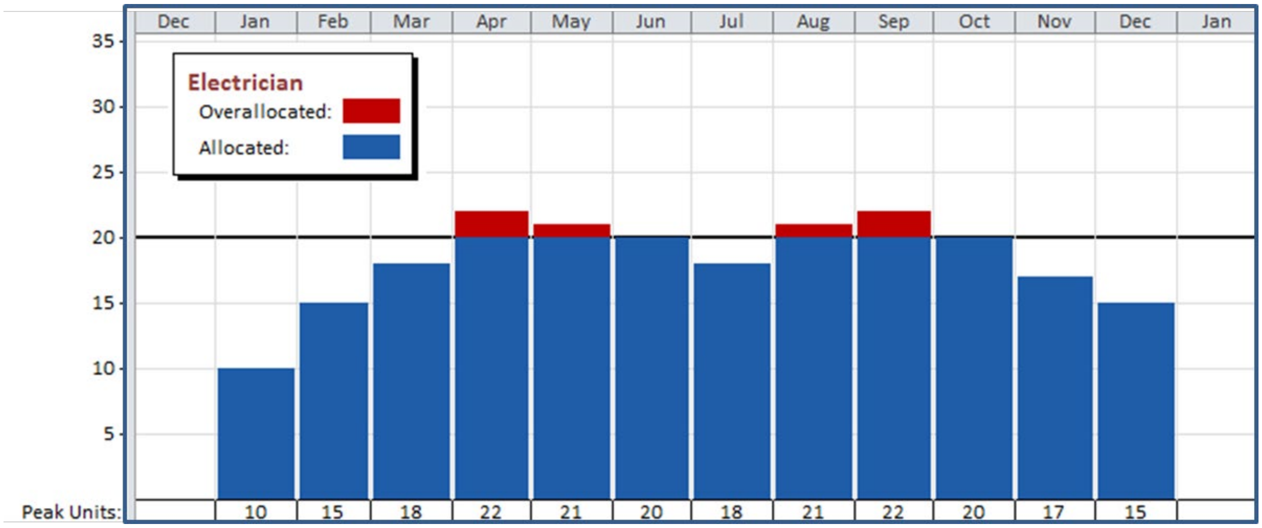


Figure 13.3-2 Example of Resource Histogram (after resource leveling is performed)

Another method is the use of soft constraints to spread resources to match a certain profile. This method will most likely create gaps in the schedules logical sequence and is recommended for use on a temporary basis to avoid resource conflicts. The final IMS will depict an achievable and efficient resourced schedule, planned according to the sequence of construction (installation) that meets project goals.

Note: If automated resource leveling is utilized, it is important to manually review and verify the leveling changes to ensure the execution plan is still achievable.

Scheduling using Commodities and Installation Curves

Commodity material resources are commonly loaded in a construction IMS to derive installation curves. Commodity material is resource loaded as a quantity (linear feet of pipe, conduit or wire, etc.). Commodity resource loading is established early in the planning process (in baseline) and progressed during construction (installation) to monitor against plan.

Commodity curves are S-curves representing quantity on the Y axis and timeline on the X axis. Similar to the labor resources, the more defined the type of commodity resource (such as pipe, conduit, wire etc.), the better isolation of commodity curves showing the applicable rate of installation for each unique commodity. Commodity curves are key in several aspects, one aspect is verifying the rate of installation with the available craft resource (or crew) that is working in a finite physical location to install the commodity material. A second aspect is identifying the need date for receipt of commodity material and the required quantity to support the plan. A third, and perhaps most important aspect, is monitoring the planned vs actual installation rate, which typically aids in management decisions on productivity. Commodity curves in a Construction Environment are essential and provides a quick and accurate monitoring tool of progress and productivity.

Lower Level Schedules

It is typical in a Construction Environment to rely on lower level schedules for the day-to-day execution and progress monitoring. Execution schedules reside outside the IMS system, they are very detailed, and usually span a short window. If lower level schedules (execution schedules) are utilized, correlation of progress, dates and scope must exist and trace back to the IMS. In many instances, lower level schedules can be used as objective measure indicators or Quantifiable Back-up Data (QBD) to status the progress of corresponding IMS tasks.

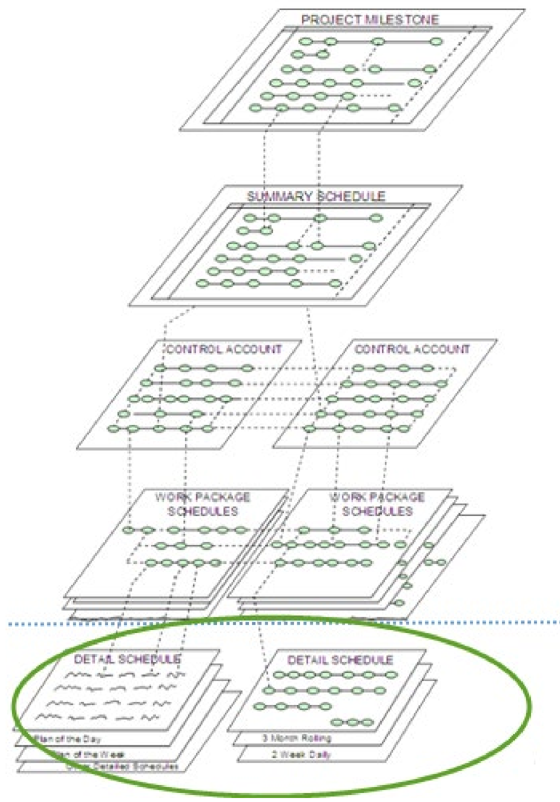


Figure 13.3-3 Example of Schedule Hierarchy

Subcontractor Schedule Integration

In a Construction Environment, it is common to have one or more subcontractors on a project, ranging from equipment suppliers, engineering subcontractor or construction (installation) subcontractors. It is likely that subcontractor schedules, including resource and cost loading, are integrated into the prime contractor IMS baseline plan at the award of the subcontract. Vertical integration must always be maintained to allow for accurate correlation between the subcontractor schedule and the IMS schedule. It is recommended to share with the subcontractor the WBS elements that represents the subcontractor scope in the prime contractor IMS schedule. This enable the subcontractor to develop their schedules according to the IMS WBS structure and eventually facilitate seamless vertical integration.

The method of integrating subcontractor schedules varies based on the complexity and risk of the subcontracted scope, subcontractor period of performance, and type of subcontract. Hence, the method of integration must be carefully evaluated. The following are three common subcontractor integration methods:

Full Schedule Transposition:

In this method, the complete subcontractor schedule is transposed into the IMS in its entirety (one-to-one correlation of tasks). The inter-relationships are then established in the IMS between the subcontractor schedule tasks and the prime contractor tasks. As the subcontractor schedule is progressed, the same tasks in the IMS are progressed with the same status of earned percent complete and remaining durations. It is common for the subcontractor to make routine (minor) execution-type changes in tasks relationships or near future durations. These are usually logistical-type changes inherent in the day-day prioritization of crews, available work areas, and minor workarounds. The routine changes must be monitored, and if approved by the prime contractor, the same changes are made in the forecast IMS schedule for correlation with the subcontractor schedule forecast and estimate to complete. This method is the most comprehensive approach and suitable for complex and high-risk scope. This method yields reasonable results if the number of tasks in the subcontractor schedule is relatively moderate.

Representative Method:

In this method, a group of tasks in the subcontractor schedule is summarized (rolled up) to one task in the IMS (many-to-one correlation of tasks). Vertical integration between the subcontractor schedule and prime contractor IMS schedule is key in this method and must be established at the early phase of the planning effort. The widely used approach to facilitate vertical integration is to define and utilize a Task code field that is common in both the subcontractor schedule and prime contractor IMS schedule. This stipulates that a subcontractor summarized task in the IMS has the same common code value as the group of tasks being summarized in the subcontractor schedule.

- For successful implementation of this method, it is key to select the appropriate level of detail for the representative summarized tasks in the IMS. The following are criteria that should be considered to establish the representative subcontractor summary tasks in the IMS:
- Tasks must depict clear handoffs among the subcontractor schedule tasks and also between the subcontractor tasks and prime contractor tasks. This can be verified by the use of finish-to-start logic, which clearly depicts the handoffs between tasks.
- The IMS tasks facilitate valid critical path analysis.
- Tasks should represent a single prevailing craft type performing the work.
- Tasks have relatively short duration.
- Tasks are planned to establish clear objective measure indicators for accurate progress reporting.
- As a general rule, tasks should be planned in the same manner as if the work is self-performed by the prime contractor that enables a road map to execution and monitoring of plan progress.
- This method is a less comprehensive approach and suitable for less complex and low to medium risk scope. Also, in this method, subcontractor routine (minor) execution-type changes are usually absorbed within the IMS summary tasks, which provides less maintenance for changes in the prime contractor IMS. This method yields reasonable results if the number of tasks in the subcontractor schedule is relatively large.

Interface Milestones Method:

This method is commonly used with equipment vendor and suppliers, mainly to represent progress points during the procurement process and equipment final delivery. This method requires establishing interface milestones, assigned a soft constraint, in the prime contractor IMS to represent interface points from the tasks in the subcontractor schedule. This method is easier to implement and maintain but provides less insight into the subcontractor's current schedule performance. This method requires manual update of each interface milestone (updating the soft constraint date) to reflect the latest forecasted dates from the subcontractor schedule. This method yields best results with less complex or lower risk subcontractor scope.

Utilizing Subcontractor Schedule of Values

In most subcontracts, the subcontractor is required to establish and submit to the prime contractor a schedule of values, demonstrating the breakdown of the subcontract cost. The schedule of values establishes the pay items upon which the subcontractor will request progress billing (invoice of actual cost), based on earned progress during execution of the subcontract work scope. It is also common in the Construction Environment, on moderate to large projects, for the subcontractor to submit a resource-loaded schedule that establishes the schedule of values at the task level and becomes the basis for substantiating progress billing. In this case, each task in the subcontractor schedule has a resource representing the lump sum cost for that task, and thus, the tasks constitute the lowest level of the schedule of values. The subcontractor may develop a roll up, through the use of task code fields, to summarize the task level schedule of values into higher-level pay items, as agreed to between the subcontractor and prime contractor. Typically, the subcontractor schedule is required to be approved by the prime contractor after subcontract award and before the subcontractor commences work.

Upon the subcontractor commencing work and throughout execution of the subcontract scope, the subcontractor statuses the schedule tasks and requests progress payments according to the progress and earned physical percent complete of each task. As explained in the previous section under "*Subcontractor Schedule Integration*", the subcontractor schedule status (progress) is transposed to the prime contractor schedule to status the tasks in the prime contractor IMS (progress percent complete, remaining duration, and forecast dates). Thus, the subcontractor schedule status provides earned value information (BCWP) in the prime contractor IMS.

It is important during the approval process of the subcontractor resource-loaded schedule that the prime contractor and subcontractor agree on the schedule of values. This ensures that the schedule of values can accurately be used in the determination of a weighted performance percent complete and establish accurate earned value on the project. A front-end loaded schedule of values may incorrectly portray an ahead (or behind) schedule position against the baseline plan. Therefore, the prime contractor must examine the subcontractor schedule of values to ensure it is based against actual physical accomplishment before it can be used to establish progress and determine earned value in the prime contractor IMS:

Rolling Wave Planning process

In general, as explained in section 9.2.2 of this guide, rolling wave planning indicates that current and near future work scope occurring in a predefined detailed planning period has significantly more detailed tasks than tasks in far future work scope. In other words, scope occurring in the detailed planning period is planned as work packages comprised of detailed tasks, and scope beyond the detailed planning period is planned as planning packages comprised of higher level detail tasks.

The planning of the complete life cycle of projects in a Construction Environment takes full advantage of the rolling wave planning process. This is inherent in the fact that early phases of a project planned in a Construction Environment further defines the scope in subsequent phases. For example, construction (installation) scope is planned at an approximate high level during conceptual design as the scope is not clearly defined. As design matures during design development, the construction scope is further defined, and the execution of construction is fully known. In this context, the detailed planning period will be during the phase where the detail scope is known (i.e. conceptual design) and the downstream phases (design development and construction) are beyond the detailed planning period. As the current phase is nearing completion, the detailed planning period is shifted to the next phase, or “event horizon”.

In a Construction Environment, there are clear breakpoints between each phase that can define the detail planning period. The following are examples of the common planning periods during the life cycle of a construction project:

- Project initiation and conceptual design
- Design development and construction contract procurement
- Construction early phases (submittals, equipment and material procurement, and early phases of a construction installation, such as site preparation, foundation, and building structure)
- Construction remaining phases
- Startup and commissioning and turnover to operations

The rolling wave planning in a Construction Environment is key as it facilitates planning the entire life cycle without burdening the IMS with unnecessary extensive downstream detail tasks that likely cannot be planned accurately during the early phases of the project life cycle.

IMS Level of Detail

The Generally Accepted Scheduling Principles (GASP) should be reviewed before deciding on the appropriate level of detail. In general, the schedule level of detail must be able to facilitate a valid and effective IMS that complies with all the tenets of the GASP. There are some guidelines that can help decide on the appropriate level of detail to include in an IMS used in the Construction Environment. Considering the rolling wave planning process, the following are some criteria that should be considered when selecting the level of detail for tasks within the detailed planning period:

- Tasks in the IMS must be comprehensive to include the complete scope.
- Tasks are clearly able to facilitate tracking and monitoring the execution of the plan from a day-to-day or week-to-week view, depending on the period of performance.
- Task definition must be concise to depict clear handoffs among other tasks. A good test is to verify that the majority of detailed tasks have straight forward relationships (finish-to-start) to other tasks. Extensive use of tasks with start-to-start or finish-to-finish relationships may be a sign that the IMS is planned at too high of a level.
- The IMS tasks must facilitate valid critical path analysis. Tasks should be able to depict driving paths with clear straight forward logic.
- Tasks should represent a single performing responsibility. In many cases, a task with multiple performing responsibility will be ambiguous to track and monitor its progress.
- Tasks should have relatively short durations, preferably one to two months long. The key is to be able to establish meaningful objective measure indicators to accurately assess progress.

The level of detail will vary from one project to another, depending on the complexity of the work scope and the length of the period of performance, nonetheless, the above criteria prevalently exists in IMS used in a Construction Environment.

Optional Techniques

The integration of external schedules (such as lower level schedules and subcontractor schedules) can be easily facilitated through the scheduling tool options to group, sort, or filter the IMS and external schedules based on common code fields. Most scheduling tools allow for multiple schedules to be viewed simultaneously; and with common code fields, a custom schedule layout can be developed to overlay two schedules at the desired breakdown. These layout views will aid in subcontractor schedule to IMS true up, verify vertical integration, and transpose progress status.

Things to Promote

Lower level schedules outside the IMS are common in a Construction Environment and should be considered to plan the day-to-day execution work.

Subcontracted work exists on most every construction project, carefully select the method of integrating subcontractor schedules into the IMS, and choose the appropriate level of detail to match the scope complexity and risk.

Plan labor resource loading into the IMS with clear breakdown by resource (craft) type to allow meaningful resource analysis of demand vs availability.

Resource loading of commodity material can aid in analyzing productivity through monitoring the planned v. actual rate of installation.

When a Schedule of Values is utilized, ensure weighting is measured against physical accomplishment.

Things to Avoid

Do not overburden the IMS schedule with abundance of unmanageable level of detail, consider rolling wave planning and the use of lower level schedules.

Subcontractor schedule of values provide a weighted approach in establishing the performance percent complete, review the subcontractor schedule of values to avoid front-end loading.

Related Topics

Resources in the Schedules
Rolling Wave Planning
Subproject/External Schedule Integration

Appendix A Terms and Definitions

The following list contains some useful terms and definitions relevant to program planning.

Activity / Task	An element of work with duration in the Integrated Master Schedule (IMS)
Backward Pass	The calculation used by the schedule software tool to determine the latest possible Start and Finish Dates for every activity in the IMS network
Contract	An awarded agreement from a government or industry customer specifying the terms and conditions of performance, including defining all clauses, delivery schedules, data products, rights to data, work scope and performance boundaries, cost share criteria, etc.
Control Account (CA)	The intersection of one WBS and one OBS representing a discrete portion of program scope assigned to an individual manager. The control account is the minimum level where technical, schedule, and cost responsibility exists.
Control Account Manager (CAM)	The individual responsible for cost, schedule and technical performance of the scope within a control account (also typically responsible for the creation, status, and maintenance of the IMS tasks within the control account)
Critical Path	The longest sequence of tasks from Time Now until the program end
Driving Path(s)	The longest sequence of tasks from Time Now to an interim program milestone
Early Start / Finish	The earliest possible start or finish date for an IMS activity
Earned Value Management	A management technique used to measure program performance and progress by combining aspects of technical (scope), schedule, cost, and execution efficiency
Finish-to-Finish (FF)	A logical relationship used in the IMS network that establishes the following rule between two activities: the succeeding task cannot finish until a preceding task finishes

Finish-to-Start (FS)	A logical relationship used in the IMS network that establishes the following rule between two activities: the succeeding task cannot start until a preceding task finishes
Forward Pass	The calculation used by the schedule software tool to determine the earliest possible Start and Finish Dates for every activity in the IMS network
Free Float	The amount of time between an activity and its next closest successor / calculated by taking the delta between an activity's Early Finish Date and Early Start Date of the its next closest successor
General Purchase (GP) Items	Off-the-shelf piece parts generally purchased in bulk
Hard Constraint	Does not allow the logic to drive the schedule (i.e. either restricts all movement or restricts movement to the right) on the constrained task.
Integrated Master Plan (IMP)	A top level program plan / hierarchy that is decomposed into program events, event accomplishments, and accomplishment criteria, the IMP is typically not time phased and often serves as the basis for the program Integrated Master Schedule (IMS)
Integrated Master Schedule (IMS)	An integrated and logical network of activities required to accomplish the program scope
Lag	A scheduling option that inserts a delay in time between two logically linked IMS activities
Late Start / Finish	The latest possible start or finish date for an IMS activity
Lead	A scheduling option that models an overlap between two logically linked IMS activities
Level of Effort	An indiscrete support type activity that automatically earns performance with the passage of time - an Earned Value Technique/Method
Line of Balance (LOB) Technique	A production management technique for collecting measuring and presenting facts related to time, cost and accomplishment – all measured against a specific plan

Master Production Schedule (MPS)	The anticipated build schedule for each product on the line
Master Production Scheduler	The individual responsible for managing the Master Production Schedule in MRP
Materials Requirement Planning (MRP)	A high-level production planning and inventory control system used to manage manufacturing processes
Manufacturing Resource Planning II (MRP II)	An expansion to MRP that adds integrated financials, MPS, rough-cut capacity planning, and capacity requirements planning
Milestone	A schedule task that has zero duration and is used as a point of reference in the IMS
Near Critical Path(s)	The second, third, fourth, (etc.) longest sequence of tasks from Time Now to the program end date
Near Driving Path(s)	The second, third, fourth, (etc.) longest sequence of tasks from Time Now to an interim program milestone
Non-Recurring Effort (NRE)	A program effort that does not repeat during the program life cycle
Organizational Breakdown Structure (OBS)	A program structure that depicts the established organizational framework
Over Target Baseline (OTB)	A Contract Budget Base (CBB) that was formally reprogrammed to include additional performance management budget and which therefore exceeds the contract target cost
Over Target Schedule (OTS)	A program schedule that was formally reprogrammed to a condition where work is scheduled and the associated budgets are time phased beyond the contract completion date.
Performance Measurement Baseline (PMB)	The time-phased budget plan for accomplishing the program scope, the PMB is traceable to the baseline dates in the IMS
Planner/Scheduler	The individual responsible for maintaining the Integrated Master Schedule (IMS)
Planning Package	A segmented portion of discrete program scope within a Control Account that is not yet broken down into work packages but is

	logically linked in the IMS - performance cannot be taken against a Planning Package
Program, Task, and Resource Calendars	Calendars established in the IMS used determine non-working days (i.e. holidays, weekends, etc.)
Recurring Effort	A program effort that repeats during the program life cycle
Schedule Margin	An optional technique used for insight and management of schedule risks
Schedule Margin Task	An un-resourced activity that is the Program Manager's assessment of the amount of schedule risk to a subsequent significant event
Schedule Visibility Task (SVT)	An un-resourced activity representing effort that is not part of the budgeted program scope, but is related to and may potentially impact program tasks
Soft Constraint	Allows the logic to drive the schedule (i.e. restricts only movement to the left) on the constrained task.
Start-to-Finish (SF)	A logical relationship used in the IMS network that establishes the following rule between two activities: the succeeding task cannot finish until a preceding task starts (rarely used)
Start-to-Start (SS)	A logical relationship used in the IMS network that establishes the following rule between two activities: the succeeding task cannot start until a preceding task starts
Statement of Work (SOW)	An organized specification of contract requirements to be performed on a program
Summary Level Work Planning Package (SLPP)	A segmented portion of discrete program scope spanning multiple Control Accounts that has not been detail planned but that is logically linked in the IMS - performance cannot be taken against a Summary Level Planning Package
Task Owner	The individual responsible for executing a task
Time Now	The date that the scheduling tool treats as "today" (also known as the update, data, or status date) - all dates "to the left" of Time

	Now are considered by the scheduling tool to be "in the past" - all dates "to the right" of Time Now are considered by the scheduling tool to be "in the future"
Toll Gate Milestones	Milestones that constitute the start or completion of work scope and serve as an objective criterion for determining accomplishment - Toll Gate milestones aid in analyzing and managing complex Integrated Master Schedules
Total Float	Is defined as the number of workdays an activity's finish date can slip before impacting the program's end date, it is calculated by taking the delta between an Activity's Late Finish date and Early Finish date - it is also known as Total Slack
Work Breakdown Structure (WBS)	A product-oriented program structure that depicts the subdivision of effort required to accomplish the program scope
Work Package	A segmented portion of discrete program scope within a Control Account that is broken down into logically linked activities in the IMS – performance is taken against work packages

Appendix B References

The following is a list of recommended references to accompany this guide.

DI-MGMT-81650, Integrated Master Schedule

DI-MGMT-81861A, Integrated Program Management Report (IPMR)

IPMR Implementation Guide

DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide

GAO Scheduling Best Practices

GAO Cost Estimating and Assessment Guide

DCMA EVMS Standard Surveillance (EVAS) Instruction

NAVAIR Scheduling Guide

Navy CEVM Analysis Toolkit

NASA Scheduling Guide (NASA/SP-2010-3403)

EIA-748 Standard for Earned Value Management Systems

NDIA IPMD EVMS Intent Guide

Earned Value Management System Interpretation Guide (EVMSIG)

MIL-STD 881 Work Breakdown Structure

Risk Management Guide for DoD Acquisition

PMI PMBOK

DoD Guide to Integrated Product and Process Development

Defense Acquisition Guidebook

Defense Acquisition Program Support Methodology

NDIA IPMD Surveillance Guide

DoD Over Target Baseline / Over Target Schedule Handbook

NDIA IPMD Integrated Baseline Review (IBR) Guide

DAU EVMS Gold Card

DAU 262 White Card

Appendix C PASEG to GASP Roadmap / Matrix

PASEG		GASP							
		Valid					Effective		
#	Chapter Name	Complete	Traceable	Transparent	Statused	Predictive	Usable	Resourced	Controlled
1	Purpose & Scope	X	X	X	X	X	X	X	X
2	Generally Accepted Scheduling Principles (GASP)	X	X	X	X	X	X	X	X
3	Leadership, Buy-in, & Commitment								
3.1	Managing Using an IMS				X	X	X	X	
3.2	The IMS is a Tool, not Just a Report			X	X	X	X		X
3.3	Integration of Management Tools	X	X	X	X	X	X	X	X
3.4	Roles and Responsibilities of Program Personnel						X		X
4	Schedule Architecture								
4.1	IMS Architecture	X	X	X	X	X	X	X	X
4.2	Integrated Master Plan (IMP)	X	X						X
4.3	Schedule Hierarchy	X	X	X	X	X	X	X	X
4.4	Baseline vs. Forecast Schedules	X	X	X	X	X	X	X	X
4.5	Top Down vs. Bottom up Planning	X	X			X	X	X	X
5	Schedule Modeling Techniques								
5.1	Task Naming Convention	X		X			X		X
5.2	Task Duration	X			X	X		X	X
5.3	Relationships / Logic		X	X		X	X		X
5.4	Lead / Lag Time		X	X		X	X		X
5.5	Task Constraints		X	X		X	X		X
5.6	Milestones	X	X	X		X	X		X
5.7	Summaries & Hammocks	X	X	X			X		
5.8	Level of Effort (LOE)	X	X	X				X	X
5.9	Apportioned Effort	X	X	X				X	X
5.10	Working Calendars	X	X	X		X	X	X	X
5.11	Schedule Calculation Algorithm			X	X	X	X	X	X
5.12	Schedule Margin	X	X	X	X	X	X		X
6	Cost & Schedule Resource Integration								
6.1	Intro to Cost/Schedule Resource Integration	X		X			X	X	X
6.2	Resources in the Schedule	X		X			X	X	X
6.3	Resources Not in the Schedule	X		X			X	X	X
7	External Schedule Integration								
7.1	Subproject/External Schedule Integration	X	X	X	X	X	X	X	X
7.2	Interface Handoff Milestones	X	X	X		X	X		X
7.3	Schedule Visibility Tasks (SVT)	X	X	X		X	X		X
8	Horizontal & Vertical Traceability								
8.1	Horizontal Traceability	X	X			X	X		X
8.2	Vertical Integration & Traceability	X	X		X	X	X		X
8.3	Task Coding	X	X			X		X	X

PASEG		GASP							
		Valid					Effective		
#	Chapter Name	Complete	Traceable	Transparent	Statused	Predictive	Usable	Resourced	Controlled
9	Schedule Maintenance								
9.1	Statusing								
9.1.1	Statusing to Timenow				X	X			X
9.1.2	Forecasting				X	X			X
9.1.3	Schedule Acceleration Techniques			X			X	X	X
9.1.4	Estimate at Completion				X	X	X	X	X
9.2	Baseline Maintenance								
9.2.1	Baseline Change Management	X		X			X	X	X
9.2.2	Rolling Wave Planning	X	X	X			X	X	X
10	Schedule Analysis								
10.1	Critical & Driving Path Analysis		X	X	X	X	X		X
10.2	Schedule Health Assessment	X	X	X	X	X	X	X	X
10.3	Risk & Opportunity								
10.3.1	Incorporation of Risks & Opportunities	X		X			X	X	X
10.3.2	Schedule Risk Assessment (SRA) – Setup & Execution		X	X	X	X	X	X	
10.3.3	Schedule Risk Assessment (SRA) – Analysis					X	X		
10.4	Schedule Execution Metrics								
10.4.1	Intro to Schedule Execution Metrics	X	X	X	X	X	X	X	X
10.4.2	Critical Path Length Index (CPLI)					X	X		
10.4.3	Schedule Performance Index (SPI)				X	X	X		
10.4.4	Baseline Execution Index (BEI)				X	X	X		
10.4.5	Current Execution Index (CEI)				X	X	X		
10.4.6	Total Float Consumption Index (TFCI)				X	X	X		
10.4.7	Duration-Based vs. Scope-Based Percent Complete			X	X	X	X	X	X
10.4.8	Schedule Rate Chart				X	X	X		
10.4.9	Time-Based Schedule Performance Index (SPI_t)				X	X	X		
10.4.10	SPIt vs. TSPIt				X	X	X		
10.4.11	Independent Estimated Completion Date ($IECD_{es}$)				X	X	X		
11	Business Rhythm & Submittal								
11.1	IMS Supplemental Guidance			X					X
11.2	Desktop Procedures			X					X
11.3	Submittal of IMS Data			X	X	X	X	X	X
11.4	Business Rhythm				X	X	X		X
11.5	Program Schedule Reviews				X	X	X		X
12	Training								
12.1	Leadership Training			X	X	X	X		X
12.2	Planner/Scheduler Skills & Training						X		X
13	Program & Contract Phase Considerations								
13.1	Proposal IMS Considerations	X	X	X	X	X	X	X	X
13.2	Scheduling in a Production Environment	X	X	X	X	X	X	X	X

Appendix D Credits and Acknowledgements

Special thanks and credit for all of the Industry and Government Subject Matter Experts who provided necessary comments, corrections and feedback that has made this document the state of the art best-practice Planning and Scheduling guide for the Defense Industry.

