

GAO Agile Assessment Guide: Applications for Cost Estimating, Scheduling, and Earned Value Management

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Outline

- Background (GAO)
- Best Practice Guides
- Agile Guide Overview
- Deeper Dive: Program Controls
 - Work breakdown structure
 - Cost estimating
 - Scheduling
 - Earned value management



Background

Overview: About GAO

- GAO is an independent, nonpartisan agency serving the Congress to help improve the performance and ensure the accountability of the federal government
- Core values are Accountability, Integrity, and Reliability
- To ensure independence, the Comptroller General (CG) is appointed to a 15-year term by the President. Other than the CG, there are no political appointees at GAO



Oversight, Insight, Foresight

Overview: About GAO (Our Work)

- GAO work is primarily done at the request of congressional committees or subcommittees or is mandated by public laws or committee reports. We also undertake research under the authority of the Comptroller General.
- Some examples of our work include:
 - Auditing agency operations to determine whether federal funds are being spent efficiently and effectively
 - Investigating allegations of illegal and improper activities
 - **Reporting on how well government programs and policies are meeting their objectives**
 - **Performing policy analyses and outlining options for congressional consideration**
 - Issuing legal decisions and opinions, such as bid protest rulings and reports on agency rules
- In 2018, Congress directed the formation of the Science, Technology Assessment, and Analytics (STAA) team, recognizing that the accelerating pace of innovation has created a need for more and deeper analysis of science and technology

More information about GAO can be found at www.gao.gov



Best Practice Guides

Overview: Best Practice Guides

Why develop best practice guides?

- Legislators, government officials, and the public want to know whether government programs are achieving their goals and what these programs are expected to cost and when they are expected to be finished.
 - Best practice guides provide clear criteria to establish the quality of program artifacts and whether they provide managers and oversight organizations enough information to make informed decisions.
- Developing reliable program cost and schedule estimates is critical to
 - Effectively using public funds.
 - Meeting OMB's capital programming process.
 - Avoiding cost overruns, missed deadlines, and performance shortfalls.
- The Guides help provide a framework for managing the government's acquisition efforts and ensuring the successful development and integration of cutting-edge technologies and their integration into large and complex systems.

Overview: Best Practice Guides

- **Cost Estimating and Assessment Guide**
 - Issued: March 2020, GAO-20-195G
- **Schedule Assessment Guide**
 - Issued: December 2015, GAO-16-89G
- **Technology Readiness Assessment Guide**
 - Issued: January 2020, GAO-20-48G
- **Agile Assessment Guide**
 - Issued: November 2023, GAO-24-105506





Agile Guide Overview

GAO Agile Assessment Guide: Chapters

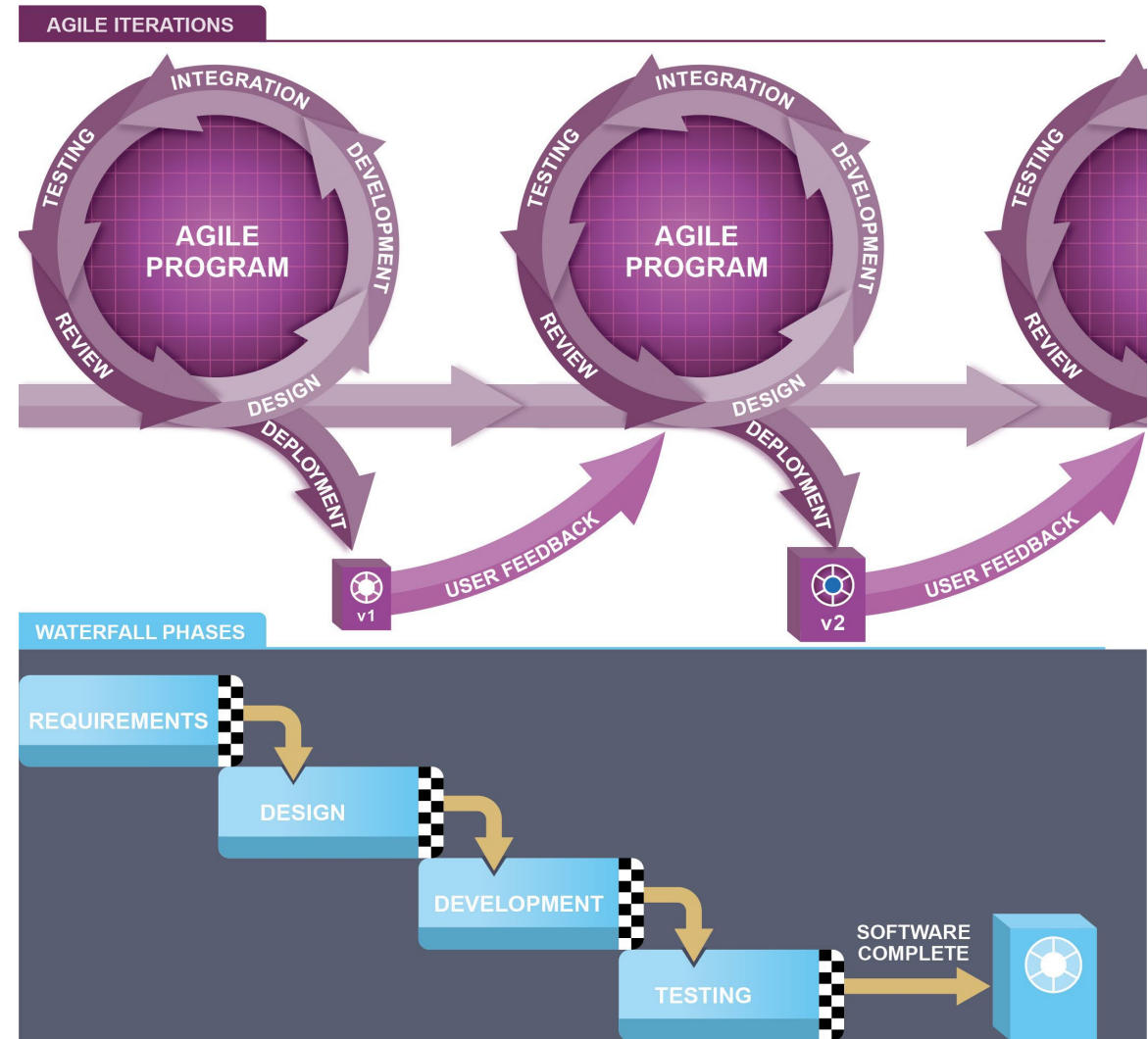
- Chapter 1: Background
- Chapter 2: Agile Adoption Challenges in the Federal Government and Actions Taken in Response
- Chapter 3: Agile Adoption Best Practices
 - Team activities, Program processes, and Agency environment
- Chapter 4: Overview of Agile Execution and Controls
- Chapter 5: Requirements Development and Management in Agile
- Chapter 6: Agile and the Federal Acquisition Process
- **Chapter 7: Agile Program Monitoring and Control**
 - Work Breakdown Structure (WBS), Cost estimating, Scheduling, and Earned Value Management (EVM)
- Chapter 8: Agile Metrics

GAO Agile Assessment Guide: Appendixes

- Appendix I: Objective, Scope, and Methodology
- Appendix II: Key Terms
- Appendix III: Related Terms
- Appendix IV: Auditor's Key Questions and Effects
- Appendix V: Common Agile Frameworks
- Appendix VI: Debunking Agile Myths
- Appendix VII: Background for Case Studies and Agile in Action
- Appendix VIII: Specialists Who Helped Develop this Guide
- Appendix IX: GAO Contacts and Staff Acknowledgements

GAO Agile Assessment Guide: What is Agile?

- Agile software development is an approach to developing and delivering software that allows stakeholders to validate requirements, processes, and system functionality in increments, and deliver functionality to users in shorter cycles
- Software development in the government has traditionally followed a “waterfall” approach. This approach typically involves sequential phases, often with delivery of working software years after development begins



Source: GAO analysis of DOD and USCIS Information.t | GAO-24-105506

GAO Agile Assessment Guide: Key Terms

- **Road map:** A high level plan that outlines a set of releases and the associated features. The road map is intended to be continuously revised as the plan evolves.
- **Release:** A planning segment of requirements that deploys needed capabilities. The release is a time boxed event that consists of a set number of iterations that are determined by the program. The **release plan** is where different sets of usable functionality or products are scheduled to be delivered to the customer.
- **Backlog:** The backlog is a list of features, user stories, and tasks to be addressed by the team, program or portfolio and is ordered from the highest priority to the lowest priority. A backlog can occur at varying levels; for example, a product backlog is a high-level backlog that contains all the requirements for the entire program.

For more terms and definitions see the Agile Guide's Appendix II: Key Terms
It is important to define the terms with the program early because terms can vary



Deeper Dive: Program Controls

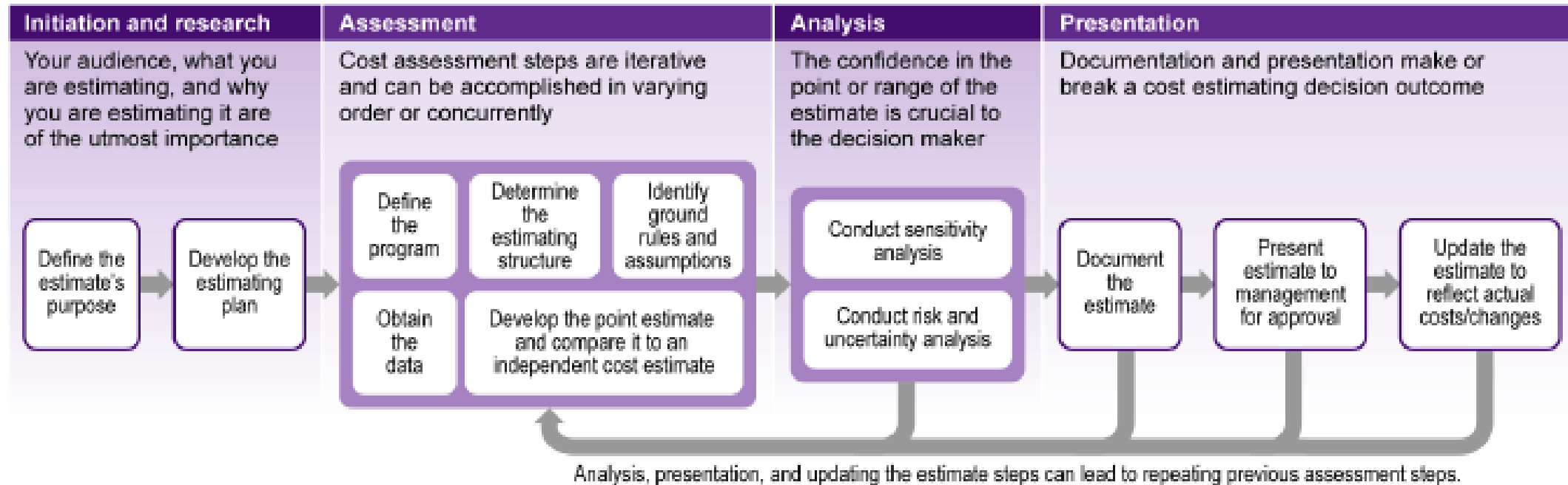
Work Breakdown Structure

Pre-release/iteration planning			Post-release/iteration planning		
WBS	Title	Release	WBS	Title	Release
1.1	Prime mission product		1.1	Prime mission product	
1.1.1	Epic 1	R1	1.1.1	Epic 1	R1
			★ 1.1.1.1	Feature 1.1	R1
			★ 1.1.1.2	Feature 1.2	R1
1.1.2	Epic 2	R1/R2	1.1.2	Epic 2	R1/R2
			★ 1.1.2.1	Feature 2.1	R1
			★ 1.1.2.2	Feature 2.2	R2
			★ 1.1.2.3	Feature 2.3	R2
1.2	Program management	All	1.2	Program management	All
1.3	Hardware	R1	1.3	Hardware	R1
1.4	Software licenses	R2	1.4	Software licenses	R2

Source: GAO. | GAO-24-105506

- A work breakdown structure (WBS) can be used by management and Agile teams to provide a clear structure of the total scope of work necessary to meet a program’s vision and requirements.
- WBS can also show the relationship between Agile development effort and other parts of the program.

Recall: 12-step Cost Estimating Process



Source: GAO. | GAO-20-195G

- From the GAO Cost Guide (GAO-20-195G), the 12 step cost estimating process

The Agile Guide provides an Agile environment example for each step

Characteristics of a Reliable Cost Estimate

Well-documented

- Cost estimates can easily be repeated or updated and can be traced to original sources through auditing

Comprehensive

- An Agile cost estimate should reflect the effort contained in the product backlog and each item in the product backlog should be directly linked through value-based high-level requirements captured in the program vision and roadmap

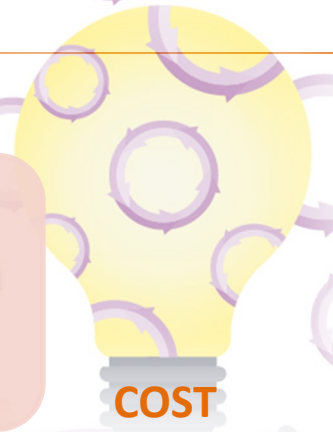
Accurate

- Historical data from other software programs should be used as input to the initial point estimate.
- Agile cost estimates should be developed in constant year dollars and appropriately time-phased to account for inflation and updated frequently as more information becomes available

Credible

- Agile cost estimates are credible when they have been tested for sensitivity, a confidence level for the point estimate has been determined, they are cross checked using another estimating methodology, and are compared to an independent cost estimate with similar results.

Cost Estimating Considerations



Consistent Sizing

- Relative estimating is typically used by developers, these methods can vary from team to team
- Relative estimating does not provide a consistent measure to develop a cost estimate

Integrate

- Cost estimators should participate in release planning sessions to understand the relationship between the backlog and developers' relative estimating techniques so that they can further reefing the total program's cost estimate

Benefits

- A reliable cost estimate provides many benefits to an Agile program
- For example, the cost estimate can be used to support the government budgeting process and help inform management decisions

Recall: 10 Scheduling Best Practices

1. Capturing all activities
2. Sequencing all activities
3. Assigning resources to all activities
4. Establishing the duration of all activities
5. Verifying that the schedule can be traced horizontally and vertically
6. Confirming the critical path is valid
7. Ensuring that total float is valid
8. Conducting a schedule risk analysis
9. Updating the schedule using actual progress and logic
10. Maintaining a baseline schedule

The Agile Guide provides an Agile environment example for each best practice

Characteristics of a Reliable Schedule

Comprehensive

- Captures all activities
- Assigns resources to all activities
- Establishes the duration of activities

Well-Constructed

- Sequences all activities
- Confirms the critical path is valid
- Ensures reasonable total float

Credible

- The schedule is traceable horizontally and vertically
- Schedule risk analysis

Controlled

- Updated with actual progress and logic
- Maintains a baseline schedule

Scheduling Considerations

Planning

- While Agile emphasizes detail planning for near term work, programs should define their overall goal in a vision and plan releases to satisfy that vision

Constraints

- Using constraints reduces the utility of the schedule as a coordination tool among Agile teams, management, and others

Assign Resources

- The schedule should include labor and non-labor resources needed to accomplish work.
- The level of detail should be commensurate with the level of detail included in the schedule

Schedule Risk Analysis

- A schedule risk analysis should be conducted throughout an Agile development program's iterative process to identify the risks, paths, and activities most likely to delay the program and to serve as a basis to determine schedule risk contingencies.

Schedule Baseline

- In creating a baseline using the rolling wave planning process, updates should contain enough detail to enable a collaborative agreement between product owners and developers without making schedule updates overly frequent or cumbersome.

Recall: 13 EVM Activities

1. Define the scope of effort with a work breakdown structure
2. Identify who in the organization will perform the work
3. Schedule the work to a timeline
4. Estimate the resources and authorize budgets
5. Determine the objective measure of earned value
6. Develop the performance management baseline
7. Execute the work plan and record all costs
8. Analyze earned value management performance data and record variances from the performance measurement baseline plan
9. Forecast estimates-at-complete using earned value management
10. Conduct an integrated cost-schedule risk analysis
11. Compare estimates-at-complete from earned value management (step 9) with estimates-at-complete from risk analysis (step 10)
12. Take management action to respond to risks
13. Update the performance measurement baseline as changes occur

The Agile Guide provides an Agile environment example for each activity

Characteristics of a Reliable EVM System

Comprehensive

- The program has a certified EVM system
- Integrated baseline review
- The schedule reflects the WBS, there is a logical sequencing of activities, planned resources are adequate
- EVM system surveillance is being performed

Accurate

- The EVM system data do not contain anomalies
- EVM system data are consistent among the various reporting formats
- Estimates-at-completion are realistic

Informative

- EVM system data are reviewed on a regular basis
- Management uses EVM system data to develop corrective action plans
- The performance measurement baseline is updated to reflect changes

EVM Considerations

Tracking WBS Detail

- Given the dynamic nature of Agile, tracking at too low a level may not yield valuable data because of the frequent changes made

Measuring EV

- The Agile Guide recommends using the percent complete method to track at the feature level and the 0/100 method to determine if a user story has been completed

Calculating Variances

- Meaningful variances require measuring performance against a baseline

Controlling Baseline Changes

- A process should be established to manage baseline changes. The goal of the process should be to preserve the integrity of the performance baseline and to ensure it reflects the most current plan so that credible performance measurement can occur

Case Studies

Cost & Schedule: Personnel Vetting
(GAO-23-105670)

Scheduling: FEMA Grants Modernization
(GAO-19-164)

Earned Value Management: F-35
(GAO-23-106047)



Case Study: Cost & Schedule

Personnel Vetting: DOD Needs a Reliable
Schedule and Cost Estimate for the
National Background Investigation Services
Program

(GAO-23-105670)

Background

- The Department of Defense, through its Defense Counterintelligence and Security Agency (DCSA), conducts personnel vetting for the majority of the federal workforce
- Since 2016, DOD has delivered some capabilities through a new information technology system- the National Background Investigation Services (NBIS) program.
 - DOD has spent over half a billion dollars on NBIS
- DOD has deployed some NBIS capabilities; however, NBIS was originally slated to be fully operational in 2019. At the time of this report, the program projects that legacy systems will be decommissioned by the end of 2024.
- In 2021, GAO recommended that DCSA develop a reliable schedule. In this report, we found that they failed to develop a reliable schedule and that their 2022 cost estimate is not reliable.



Findings: Cost

Characteristic	Score/Summary
Accurate	<p>Minimally Met: The cost estimate was based on prior budgets rather than programmatic requirements and historic program data. We also found errors in the model (e.g. discrepancies between assumptions and the cost model). Further, it was not clear how data was normalized to ensure valid comparison or that inflation was applied in a consistent way.</p>
Comprehensive	<p>Minimally Met: The estimate did not document all the ground rules and assumptions and the work breakdown structure was based on budget categories rather than NBIS products. Further, several items were excluded from the estimate, despite being programmatic requirements.</p>
Credible	<p>Not Met: While some cost drivers were examined for sensitivity, the estimate did not include a risk and uncertainty analysis, did not employ cross-checks, and was not compared to an independent cost estimate.</p>
Well-Documented	<p>Minimally Met: The estimate provided some documentation to support the methodology used to develop the estimate and inflation indexes; however, not all supporting data were adequate since they did not document data reliability. Further, there was no technical baseline and it was unclear from the documentation that management approved/reviewed the estimate.</p>



Findings: Schedule

Characteristic	Score/Summary
Comprehensive	<p>Minimally Met: There was no WBS to trace the work in the schedule to key documents. And, while the schedule included duration data, we found that not all schedules provided made proper use of calendars by including holidays. Further, the schedule was not resource loaded.</p>
Controlled	<p>Minimally Met: Of the nine schedules examined, three had a baseline date. Of those three, two had a status date and only one had a status date that occurred after the baseline date.</p>
Credible	<p>Minimally Met: We could not trace all of the schedule files horizontally because of incomplete logic. We could not trace the schedules vertically because there were differences between the schedules and schedule briefings. Further, although we received a risk register, the program did not conduct a schedule risk analysis.</p>
Well-Constructed	<p>Minimally Met: The degree of sequencing varied significantly among the different schedules; however, they all lacked logic between some activities. Further, we found that none of the schedules had a true critical path and all schedules had unreasonable float values.</p>

Conclusion

- The findings in this report resulted in a Matter for Congress:
 - Congress should consider requiring the Secretary of Defense to direct the NBIS Program Management Office to develop a reliable program schedule and cost estimate for NBIS as defined in GAO's *Schedule Assessment Guide*, *Cost Estimating Assessment Guide*, and *Agile Assessment Guide*.



Case Study: Schedule

FEMA Grants Modernization: Improvements Needed to Strengthen Program Management and Cybersecurity (GAO-19-164)

Background

- FEMA's mission is to help people before, during, and after disasters. FEMA accomplishes a large part of its mission through awarding grants to state, local, and tribal governments and nongovernmental entities to help communities prevent, prepare for, protect against, and mitigate the effects of, respond to, and recover from disasters and terrorist attacks.
- The current FEMA grants management environment is highly complex with many stakeholders, IT systems, and users.
- FEMA initiated GMM in 2015 to modernize the agency's grants management environment. The program is intended to modernize and streamline the agency's grants management environment.
- GAO was asked to
 - Determine the extent to which FEMA is implementing leading practices for reengineering its grants management processes and incorporating needs into IT requirements
 - **Assess the reliability of the program's estimated cost and schedule**
 - Determine the extent to which FEMA is addressing key cybersecurity practices



Findings

Characteristic	Rating/Summary
Comprehensive	Minimally Met: While the schedule contained both government and contractor activities, it did not align with the program’s WBS. Further, it did not include resources and many activities were missing durations.
Well-Constructed	Not Met: Approximately 82% of the schedule’s activities were not sequenced; that is, they were missing schedule logic. As a result of the missing schedule logic, there was not a valid critical path and the schedule had unreasonable total float values.
Credible	Minimally Met: The schedule was not horizontally or vertically traceable. The program office stated that they were assessing risks facing the program and mitigating them in real time as part of their Agile development process. However, they did not develop a formal schedule risk analysis to see how uncertainty and key risks affect activities in the schedule.
Controlled	Minimally Met: Officials cited ways that the status of activities were tracked and updated weekly and daily, such as by examining impediments that slow down Agile development processes. However, the schedule was not updated as part of those reviews and they did not establish a baseline schedule to measure, monitor, and report progress.

Recommendations and Agency Response

- We recommended that the FEMA Administrator ensures that the GMM program management office updates the program schedule to address the leading practices for a reliable schedule
- The GMM program management office updated the schedule
 - In February 2020, FEMA provided us with a demonstration of their new schedule
 - The program also updated the Program Management Plan to describe GMM's revised schedule management process
 - Based on the demo and the updated documents provided, we concluded that the quality of the schedule had largely improved since our last review.
 - While GMM did not address all leading practices, we found that the program had made substantial improvements to the schedule to empower leadership to make more informed resource decisions.
 - This recommendation was closed as implemented



Case Study: EVM

F-35 Joint Strike Fighter: More Actions Needed to Explain Cost Growth and Support Engine Modernization Decision (GAO-23-106047)

Case Study: Background



Initial operating capability

2016 (Air Force)

2015 (Marine Corps)

2019 (Navy)

Purpose

Counter present and future advanced threats through counter air, strike, and surveillance and reconnaissance missions

Air Force variant that supports primarily air to ground missions and comprises majority of partner aircraft and foreign military sales

Marine Corps variant that is capable of short take-off and vertical landing to support expeditionary basing ashore and deployment at sea

Navy and Marine Corps variant with larger wing span and greater fuel storage to support aircraft carrier operations and expeditionary roles

Source: GAO analysis of Department of Defense documents and interviews with officials. Photos (left to right): U.S. Air Force/Staff Sgt. Andrew Lee, U.S. Navy/Petty Officer 1st Class Jeremy Starr, and U.S. Air Force/Defense Visual Information Distribution Service. | GAO-23-106047

- The F-35 Lighting II Joint Strike Fighter is a family of 5th generation strike fighter aircraft that integrates low-observable technology with advanced sensors and computer networking capabilities
- GAO has reviewed this program annually since 2001
- In this report we:
 - Described any remaining risks with completing the original development program
 - **Assessed DOD’s progress in developing, testing, and delivering modernization capabilities and risks that remain**
 - Evaluated DOD’s plans and assessment of the options for modernizing the F-35 engine and power thermal management system

Case Study: Findings

Characteristic	Score	Summary of Assessment
Comprehensive: a comprehensive earned value management system is in place	Substantially Met	DCMA approved the program’s EVM system and is engaged in program oversight. However, while an IBR was conducted, it listed numerous concerns about a lack of holistic Block 4 program-level analysis. Further, the schedule included numerous constraints and many tasks did not have resources assigned.
Accurate: the data resulting from the earned value management system are reliable	Partially Met	The data was consistent across the different IPMR formats. However, there were numerous anomalies in every report that GAO reviewed. Additionally, the contractor EAC was low compared to the range of EACs GAO developed.
Informative: the program management team is using earned value management system data for decision-making purposes	Substantially Met	The program office reviewed the EVM data provided by the contractor. However, the analysis did not consider how to address problems. And, while the PMB is updated to reflect changes, we found large increases to the PMB and frequent baseline change plans made the data difficult to interpret.



Case Study: Additional Concerns & Recommendations

- The performance measurement baseline is updated to reflect changes
 - Many changes to the PMB complicated the analysis of the program going forward
 - Baseline changes are significant and have the potential to distort metrics reported by the program

GAO recommended (among other things) that the F-35 program office report to Congress on cost differences between original estimate and actual costs for a defined group of modernization capabilities over time

Thank you

Guides Available Online and Downloadable in PDF:

GAO Cost Estimating and Assessment Guide:

<https://www.gao.gov/products/gao-20-195g>

GAO Schedule Assessment Guide:

<https://www.gao.gov/products/gao-16-89g>

GAO Technical Readiness Assessment Guide:

<https://www.gao.gov/products/gao-20-48g>

GAO Agile Assessment Guide:

<https://www.gao.gov/products/gao-24-105506>



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Back Up

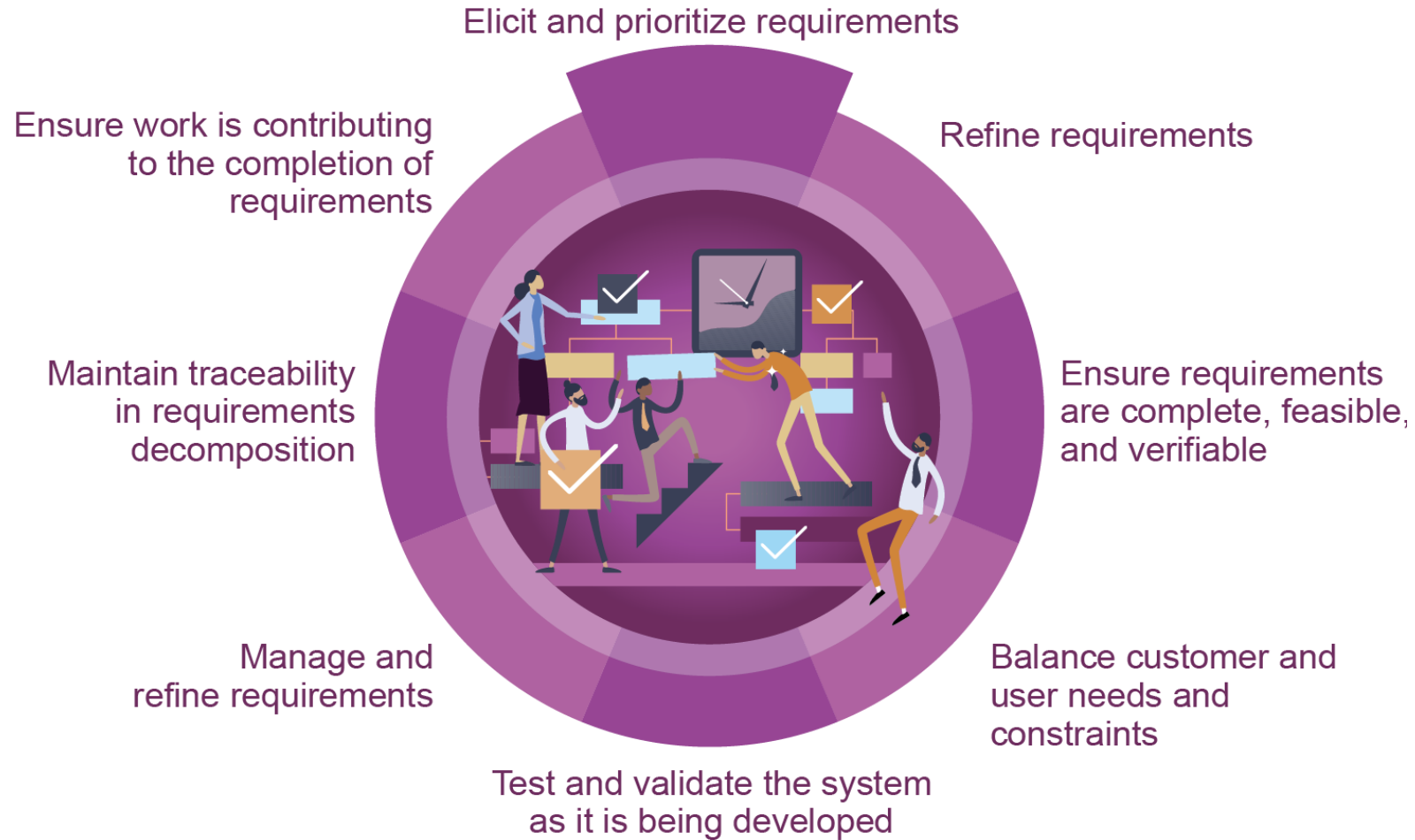
Best Practices: Agile Adoption



Source: GAO analysis of agency and private sector information (data); Vectormine/stock.adobe.com (images). | GAO-24-105506



Best Practices: Requirements Management



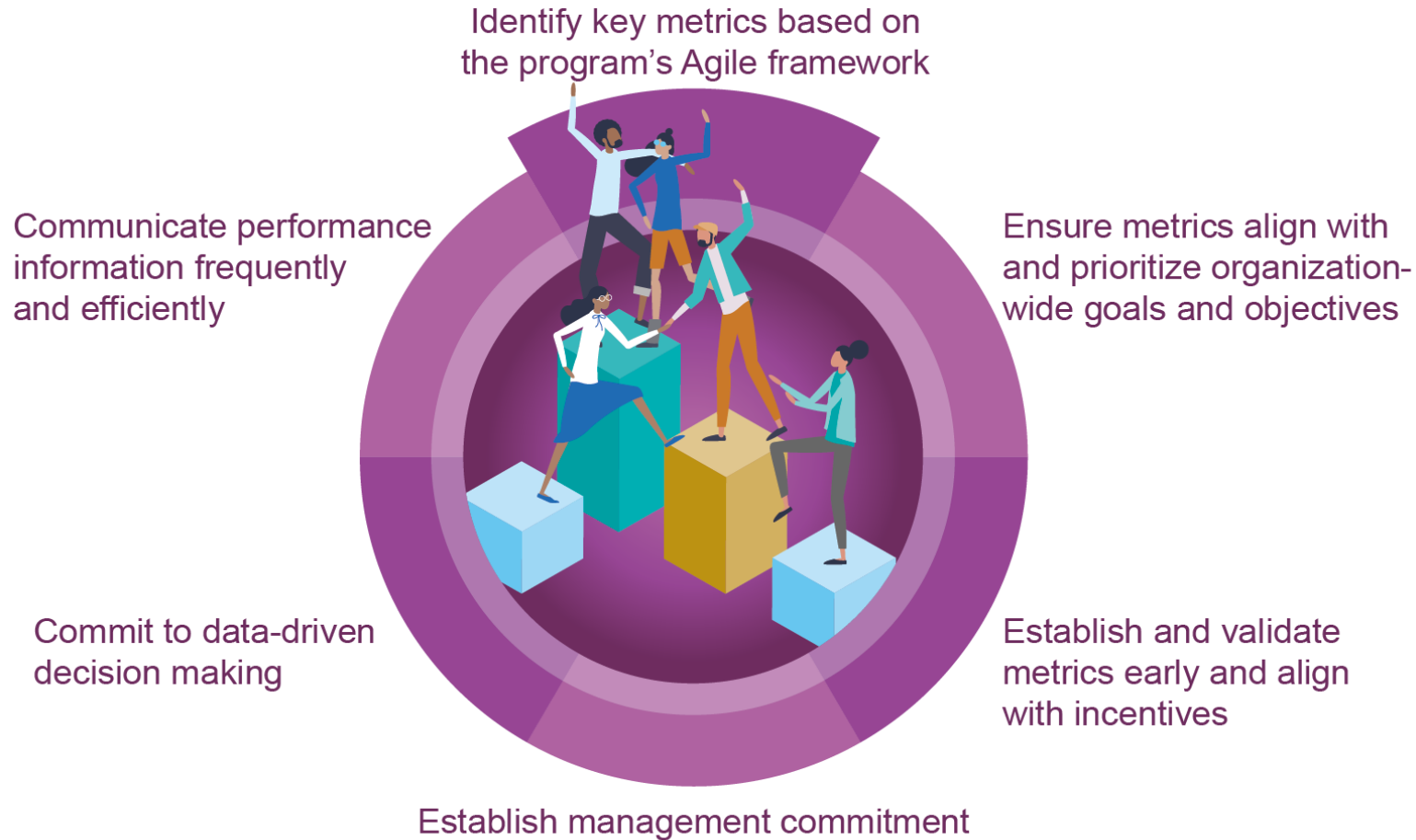
Source: GAO analysis of CMMI v. 1.3, PMI and SEI documentation (data); Vectormine/stock.adobe.com (images). | GAO-24-105506

Best Practices: Contracting



Source: GAO analysis of agency and private sector information (data); Vectormine/stock.adobe.com (images). | GAO-24-105506

Best Practices: Metrics



Source: GAO analysis of agency and private sector information (data); Vectormine/stock.adobe.com (images). | GAO-24-105506

Agile Examples: Cost Estimating Steps (Table 10)

Step	Agile environment example
Step 1:	During release or initial planning, determine how any cost estimates will be used
Step 2:	During initial planning, identify the cost estimating team that will develop the estimate and any technical experts that will be needed to support the estimating effort. The estimate plan should also include details about when the government program office plans to update the estimate with Agile metrics.
Step 3-7:	Steps 3-7 should first occur during initial program planning with the development of a road map or vision and be updated as the estimate is refined at established intervals. Such as after a release, in support of program milestone review, or whenever there are updates to the road map. Agile performance measures and artifacts such as burn up/burn down charts, velocity metrics, and the product backlog can be used to update the estimate accordingly.





Agile Examples: Scheduling Best Practices (Table 13)

Schedule best practice	Agile environment	Examples of artifacts and documentation
Capture all activities	During planning, work on the road map should be prioritized with input from stakeholders and subject matter experts. The schedule should include epics and features from the road map that are linked to the contract, the backlog, and all organization-specific tasks.	Road map, WBS, prioritized backlog
Sequence all activities	The program schedule should reflect work at the epic and feature levels. The order of work should align with the prioritization included in the road map and backlog. Additionally, any key dependencies between features should be identified, where applicable.	Kanban board (or similar), government oversight documents, road map, prioritized backlog
Assign resources to all activities	During release planning, each team member should assess their availability for development activities with respect to other commitments (e.g. vacations, holidays, and other leave). Additionally, those assessments should account for team facilitator and other subject matter experts that could be needed to complete the planned work.	Kanban board (or similar), team calendars, project management software tailored for Agile to track user stories and resources

EVM Activities Example: Activities 1 & 2

EVM Activity	Agile environment example
Activity 1: Define the scope of effort with a work breakdown structure	The work breakdown structure (WBS) should be based on the prioritized backlog; however, the WBS should not extend below the feature level. Lower levels, such as user stories, should not be in the WBS, but metrics from these levels provide quantifiable backup data for measuring performance at the feature level and higher.
Activity 2: Identify who in the organization will perform the work	As in conventional programs, work assignments should be consolidated at the level of a control account manager. This is often done during iteration and release planning sessions and tracked in Agile program management tools.

GAO EVM Best Practices & F35 EVM Review



Characteristic	Best Practice
Comprehensive: a comprehensive earned value management system is in place	The program has a certified earned value management system
	An integrated baseline review verified that the baseline budget and schedule capture the entire scope of work, risks were understood, and available and planned resources were adequate
	The schedule reflects the work breakdown structure, the logical sequencing of activities, and the necessary resources
	EVM system surveillance is being performed
Accurate: the data resulting from the earned value management system are reliable	EVM system data do not contain anomalies
	EVM system data are consistent among various reporting formats
	Estimates-at-complete are realistic
Informative: the program management team is using earned value management system data for decision-making purposes	EVM system data are reviewed on a regular basis
	Management uses EVM system data to develop corrective action plans
	The performance management baseline is updated to reflect changes

Colors indicate the score for the recent F35 review (see GAO-23-106047). Dark green = met, light green = substantially met, yellow = partially met

Debunking Agile Myths (Appendix 6)

- **Myth:** Agile does not require planning
 - As with any approach, planning is a vital aspect that will greatly diminish the effectiveness of a successful implementation if not done appropriately.
 - Agile spreads planning activities (e.g. what specific functionality will be delivered when) more evenly throughout the program life cycle.
 - High-level planning is completed at the beginning of an Agile program and is continuously elaborated on throughout the program as new information becomes available.

Debunking Agile Myths (Appendix 6)

- **Myth:** A schedule baseline cannot be reliably developed or used for an Agile software development effort
 - A central tenet of Agile is to welcome change. As part of this, teams practice rolling wave planning. This helps to minimize the cost of changing plans, but frequent changes can appear to be in conflict with the concept of adhering to a baseline.
 - However, welcoming change does not mean that software is developed and delivered in an undisciplined or ad hoc manner.
 - A baseline should be created and approved in concert with the rolling wave planning process and it should contain enough detail to enable a collaborative agreement between product owners and developers without making schedule updates overly frequent or cumbersome.

Debunking Agile Myths (Appendix 6)

- **Myth:** Earned value management is not compatible with Agile programs
 - EVM is an important management tool that provides performance measurement information for a program.
 - While EVM tracks program performance to a fixed point in time, using an Agile approach does not preclude the need for a disciplined approach for performance measurement processes. This is especially true for government Agile programs. While scope is flexible for an iteration, often scope is not flexible for the overall program.
 - The team must differentiate requirements to identify flexibility in the scope; a tailored EVM approach can leverage EVM's benefits for Agile programs.