



March 2014

ARCHITECT OF THE CAPITOL

Incorporating All
Leading Practices
Could Improve
Accuracy and
Credibility of Projects'
Cost Estimates

GAO Highlights

Highlights of [GAO-14-333](#), a report to congressional committees

Why GAO Did This Study

AOC is responsible for the maintenance, renovation, and new construction of the U.S. Capitol complex, which comprises more than four dozen facilities. Reliable cost estimates for projects are crucial to AOC's capital-planning and construction processes. The House Appropriations Committee report accompanying the fiscal year 2014 Legislative Branch Appropriations bill mandated that GAO review AOC's cost-estimating methodology.

This report addresses the extent to which AOC's policies and guidance for developing cost estimates adheres to leading practices. GAO analyzed AOC's cost-estimating guidance, interviewed AOC officials, and compared AOC's cost-estimating guidance and documentation and two projects' cost estimates to leading practices in GAO's *Cost Guide*. When most or all of the practices associated with each characteristic of a high-quality, reliable estimate are followed, GAO considers the characteristic to be "fully" or "substantially" met. When, in turn, all four characteristics are at least "fully" or "substantially" met, GAO considers a cost estimate to be reliable.

What GAO Recommends

GAO recommends that AOC incorporate additional leading practices into its cost-estimating guidance and submit the confidence levels of project estimates to Congress. AOC concurred with the recommendations and provided context and clarification on its cost-estimating guidance and policies.

View [GAO-14-333](#). For more information, contact Lorelei St. James at (202) 512-2834 or stjamesl@gao.gov

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Incorporating All Leading Practices Could Improve Accuracy and Credibility of Projects' Cost Estimates

What GAO Found

GAO's *Cost Estimating and Assessment Guide (Cost Guide)* defines 12 leading practices that are associated with four characteristics—*comprehensive*, *well documented*, *accurate*, and *credible*—that are important to developing high-quality, reliable project-cost estimates. Using the *Cost Guide*, GAO determined that the Architect of the Capitol's (AOC) cost-estimating guidance conforms to leading practices for developing estimates that are, in general, *comprehensive* and *well-documented*. However, AOC's guidance does not substantially conform to leading practices related to developing cost estimates that are *accurate* and *credible*. For example, pertaining to the *credible* characteristic, AOC's guidance does not require determining the confidence level of estimates or quantifying the extent to which a project's costs could vary due to changes in key assumptions. GAO found the strengths and weaknesses of AOC's guidance generally reflected in the cost estimates for AOC's Cannon House Office Building's (Cannon Building) renewal project (\$753 million) and Capitol Dome's restoration project (\$125 million).

- Cannon Building renewal—GAO found the estimate is substantially comprehensive, well documented, and accurate, but several factors that affect its *credibility* are lacking. For example, AOC's risk analysis does not allow for determination of which risks have the greatest influence on project costs and may overstate the effect of the risks.
- Capitol Dome restoration—GAO found the estimate is substantially comprehensive and well documented, but lacking key analysis that support accurate and credible estimates. For example, AOC did not use actual costs from completed phases to update its estimates and did not complete a risk and uncertainty analysis.

Overall, AOC's cost-estimating guidance may not enable fully reliable estimates because it incorporates some, but not all, leading practices. Without reliable cost estimates that convey their confidence levels, AOC's projects risk experiencing cost overruns or budget surpluses, missed deadlines, and performance shortfalls. Potential limitations in the reliability of AOC's estimates may make it difficult for Congress to make well-informed funding decisions and affect how AOC allocates resources across competing projects in its capital portfolio.

GAO's Assessment of AOC's Cost-Estimating Characteristics in Its Guidance for Two Project Cost Estimates

Characteristic	AOC's guidance	Cannon Office Building	Capitol Dome
Comprehensive	●	●	●
Well documented	●	●	●
Accurate	◐	●	◐
Credible	◑	◐	◑

Source: GAO analysis of AOC documents and data.

●= Fully Meets ◐=Substantially Meets ◑=Partially Meets ◒=Minimally Meets ○= Does Not Meet

Note: A characteristic is fully met when the associated tasks of underlying leading practices are completely satisfied; substantially met when a large portion of the associated tasks are satisfied; partially met when about half of the associated tasks are satisfied; minimally met when a small portion of the associated tasks are satisfied; and not met when none of the associated tasks are satisfied.

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Abbreviations

AOC	Architect of the Capitol
EAC	estimate at completion
EVM	earned value management
FCA	facility condition assessment
ICE	independent cost estimate
LCCE	life-cycle cost estimate
WBS	work breakdown structure

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March 25, 2014

The Honorable Jeanne Shaheen
Chairwoman
The Honorable John Hoeven
Ranking Member
Subcommittee on Legislative Branch
Committee on Appropriations
United States Senate

The Honorable Tom Cole
Chairman
The Honorable Debbie Wasserman Schultz
Ranking Member
Subcommittee on Legislative Branch
Committee on Appropriations
House of Representatives

The Architect of the Capitol (AOC) is responsible for the maintenance, renovation, and new construction of the U.S. Capitol complex in Washington, D. C., which comprises more than four dozen facilities. Among the major projects involving these facilities, AOC has begun work restoring the dome atop the U.S. Capitol (Capitol Dome) and designing the renewal of the Cannon House Office Building (Cannon Building). AOC currently estimates the Capitol Dome and Cannon Building project costs to be \$125 million and \$753 million, respectively.¹

Reliable cost estimates are crucial for supporting AOC's capital planning and construction processes. Without a reliable cost estimate, an AOC project is at risk of experiencing cost overruns, budget surpluses, missed deadlines, and performance shortfalls. Furthermore, AOC's ability to generate reliable cost estimates is important to informing Congress' funding decisions and enabling AOC to effectively allocate resources

¹For the purposes of this report, a cost estimate is the summation of individual cost elements, using established methods and valid data, to estimate the future costs of a program, based on what is known today. AOC's estimates for the Capitol Dome restoration and Cannon Building renewal include costs for planning, design, construction, and implementation. Implementation includes costs for construction contract administration, testing, inspection, and quality control.

across competing projects in its capital program. The House Appropriations Committee report accompanying the fiscal year 2014 Legislative Branch Appropriations Bill (H.R. 2792) mandated that we review AOC's cost-estimating methodology to ensure that AOC is accounting for all of the variables that should contribute to a project's cost estimates.² This report addresses the extent to which AOC's policies and guidance for developing cost estimates conform to leading practices identified in GAO's *Cost Estimating and Assessment Guide*³ and provide a reliable basis to support funding and capital program decisions. This report also examines whether the estimates for the Capitol Dome and the Cannon Building projects reflect leading practices.

In conducting our study, we reviewed AOC's policies and guidance for developing cost estimates and interviewed AOC officials. To determine the extent to which AOC's policies and guidance comply with practices for cost estimating, we compared them to the leading practices set forth in GAO's *Cost Estimating and Assessment Guide (Cost Guide)*.⁴ The *Cost Guide* identifies 12 leading practices that represent work across the federal government and private sector and that have been found to be the basis for a high-quality, reliable project cost estimate. An estimate created using the leading practices exhibits four broad characteristics: it is *comprehensive, well documented, accurate and credible*. That is, each characteristic is associated with a specific set of leading practices. In turn, each leading practice is made up of a number of specific tasks. (See appendix I for a listing of the tasks that make up each of the 12 leading practices.) When the tasks associated with the leading practices that define a characteristic are mostly or completely satisfied, we consider the characteristic to be "substantially" or "fully" met. When all four

²H. R. Rep. No. 113-173, at 11 (2013).

³GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, [GAO-09-3SP](#) (Washington, D.C.: March 2009).

⁴[GAO-09-3SP](#).

characteristics are at least “substantially met”—we consider a cost estimate to be reliable.⁵

We also examined AOC’s cost estimates for two major capital projects: the Cannon Building renewal and the Capitol Dome restoration. We selected these projects based on their significance to the Capitol complex, comparatively high costs, and public visibility. In addition, our review of the Cannon Building’s renewal estimate is responsive to another mandate in the House Appropriations Committee report accompanying the fiscal year 2010 Legislative Branch Appropriations Bill (H.R. 2918) requiring us to monitor the progress of the project.⁶ We selected versions of the estimates to review that had the most complete information for our assessments. We assessed the reliability of data used in developing the estimates and found them to be sufficiently reliable for the purposes of this report. For example, while some source data were unavailable to us, we were able to assess AOC’s process for building its estimates with the data and check for errors. We also interviewed AOC staff and its technical consultant about these projects and observed existing conditions at the Cannon Building and Capitol Dome. While our review of these projects’ cost estimates provides key insights and illustrates recent products of AOC’s cost-estimating policies and guidance, the results of our review should not be used to make generalizations about all AOC project cost estimates.

We conducted our work from September 2013 to March 2014 in accordance with all sections of GAO’s *Quality Assurance Framework* that are relevant to our objectives. The framework requires that we plan and perform the engagement to obtain sufficient and appropriate evidence to meet our stated objectives and to discuss any limitations in our work. We

⁵We established five descriptions for our assessments of leading practices and cost estimate characteristics: Fully Meets, Substantially Meets, Partially Meets, Minimally Meets, and Does Not Meet. We consider a leading practice to be fully met when the associated tasks are completely satisfied; substantially met when a large portion of the associated tasks are satisfied; partially met when about half of the associated tasks are satisfied; minimally met when a small portion of the associated tasks are satisfied; and not met when none of the associated tasks are satisfied. Our assessment method weights each leading practice equally and bases the assessment of each characteristic on the average score of underlying leading practices. We assign each description a numerical value (5 for Fully Meets to 1 for Does Not Meet) and round scores to the higher numerical value (i.e., a score of 4.5 would round up to 5).

⁶H. R. Rep. No. 111-160, at 21 (2009).

believe that the information and data obtained, and the analysis conducted, provide a reasonable basis for any findings and conclusions in this product. Appendix II provides a more detailed description of our scope and methodology.

Background

Cost-Estimating Leading Practices

The *GAO Cost Estimating and Assessment Guide*⁷ explains how four characteristics of a high-quality, reliable cost estimate can be understood in relation to 12 leading practices. The extent to which an agency meets the leading practices underlying each characteristic determines its performance for that characteristic.⁸ For example, we consider the comprehensive characteristic to be “substantially met” if the organization substantially meets the underlying leading practices of (1) developing an estimating plan and (2) determining an estimating structure. Because the leading practices are separate and discrete, an agency’s performance in each of the characteristics can vary. For example, an organization’s cost estimating methodology could be found to be comprehensive and well documented, but not accurate or credible, resulting in the organization producing cost estimates of limited reliability. Table 1 illustrates the relationship of the 12 leading practices to the four characteristics of a high-quality, reliable estimate.

Table 1: GAO’s Cost-Estimating Characteristics and Leading Practices

Four characteristics of a high-quality, reliable cost estimate	12 leading practices to develop high-quality, reliable estimates
<i>Comprehensive</i> when estimate accounts for all possible costs associated with a program, is structured in sufficient detail to ensure that costs are neither omitted nor double counted, and documents all cost-influencing assumptions.	Develop the estimating plan
	Determine the estimating structure
<i>Well documented</i> when supporting documentation explains the process, sources, and methods used to create the estimate; contains the underlying data used to develop the estimate; and is adequately reviewed and approved by management.	Define the estimate’s purpose
	Define the program’s characteristics
	Identify ground rules and assumptions
	Obtain the data

⁷GAO-09-3SP.

⁸See footnote 5.

Four characteristics of a high-quality, reliable cost estimate **12 leading practices to develop high-quality, reliable estimates**

	Document the estimate
	Present the estimate to management for approval
<i>Accurate</i> when estimate is not overly conservative or optimistic, is based on an assessment of the costs most likely to be incurred, and is regularly updated so that it always reflects the program's current status.	Develop the "point estimate" ^a
	Update the estimate to reflect actual costs/changes
<i>Credible</i> when (1) any limitations of the analysis because of uncertainty or sensitivity surrounding data or assumptions are discussed, (2) the estimate's results are cross-checked, and (3) an independent cost estimate is conducted by a group outside the acquiring organization to determine whether other estimating methods produce similar results.	Compare the point estimate to an independent cost estimate ^a
	Conduct sensitivity analysis
	Conduct a risk and uncertainty analysis

Source: GAO.

^aAs described in the *GAO Cost Estimating and Assessment Guide*, developing the point estimate and comparing it to an independent cost estimate—shown separately in the table—are separate parts of a single leading practice. For purposes of assessing the extent to which a cost estimate achieves the characteristics of a high-quality cost estimate, developing the point estimate contributes to accuracy, while comparing the point estimate to an independent cost estimate contributes to credibility. A "point estimate" is the most likely value for the cost estimate, given the underlying data.

AOC's Project Development

AOC project development consists of three stages: planning, design, and construction. According to AOC's guidance, AOC refines requirements and updates cost estimates as projects progress through these stages. AOC has guidance and requirements for cost estimates at each stage of a project's development. In general, as projects develop over time and requirements are refined, the accuracy of cost estimates is expected to increase.

Given the current fiscal environment and existing building conditions, AOC must prioritize projects in its capital program and decide to either request funding for a project or defer it while mitigating potential facility issues. For example, in fiscal year 2014, AOC requested almost \$155 million for 17 projects that AOC deemed urgent, while deferring 46 projects estimated to cost about \$172 million.⁹ Two of AOC's largest and most recognizable projects that it considers urgent are the Cannon Building renewal and the Capitol Dome restoration.

Cannon Building's Renewal

The Cannon Building, completed in 1908, is the oldest congressional office building and is occupied by members of the House of

⁹Architect of the Capitol, *Budget Justification Fiscal Year 2014* (Washington, D.C.).

Representatives and their staffs. (See fig. 1.) The building houses 142 office suites, 5 conference rooms, 4 hearing rooms, and the Caucus Room, which can accommodate large meetings. The building also provides space for a library, food service, and a health unit.

Figure 1: Cannon House Office Building, Washington D. C.



Source: Architect of the Capitol.

According to AOC planning studies, the building is plagued with serious safety, health, environmental, and operational issues that are worsening. For example, without action, essential systems for heating and cooling that are located behind walls and in mechanical rooms will continue to deteriorate, potentially negatively affecting Members of Congress, staff, and constituents. AOC has been developing the scope of the Cannon Building's renewal project since approximately 2004 when AOC's consultant conducted a facility condition assessment (FCA) that identified the building's deficiencies.¹⁰ In 2009, we reviewed AOC's progress in developing the Cannon Building project and found that while it had followed a reasonable process to plan the building's renewal such as through updating the FCA, it was important that AOC continue, as planned, to refine the project's scope and cost estimate.¹¹ Since our 2009 review, AOC has proceeded with the design phase of the project, based

¹⁰Condition assessments provide information on a facility's state of repair and are developed from inspections of structural, electrical, mechanical, plumbing, and other building systems. FCA reports typically catalog all of the deficiencies identified during the inspections along with the estimated cost to correct the problems.

¹¹GAO, *Architect of the Capitol: Plans for Renovating the Cannon House Office Building and Garages*, [GAO-09-673T](#) (Washington, D.C.: May, 6, 2009).

upon its budget of \$753 million for the planning, design, and construction phases. The project is currently expected to be completed by 2025.

According to AOC officials and current design documents, AOC plans to correct most of the Cannon Building's identified deficiencies and to address requirements such as energy conservation, physical security, hazardous materials abatement, and historic preservation. The project is to involve substantial reconfiguration of interior and exterior spaces to include reconstructing the building's top floor, which now partially consists of storage space, and landscaping the courtyard. The project is also expected to provide refurbished windows and a new roof. Additional work is intended to preserve and repair the building's stone exterior. The project is also expected to allow for complete replacement of all plumbing, heating and cooling, fire protection, electrical, and alarm systems; refurbish restrooms and make them more accessible to people with disabilities; and provide new wall and floor finishes in some areas. In addition, the project includes removing asbestos that may be contained in plaster ceilings and walls. AOC plans to conduct the work in phases corresponding to the four sections of the building and including an initial phase for utility work as shown in figure 2. Tenants displaced during construction of each section are to move to temporary offices while other occupants will remain in building sections not affected by construction.

Figure 2: Scope and Phases of AOC's Renewal Project for the Cannon Building, as of February 2014

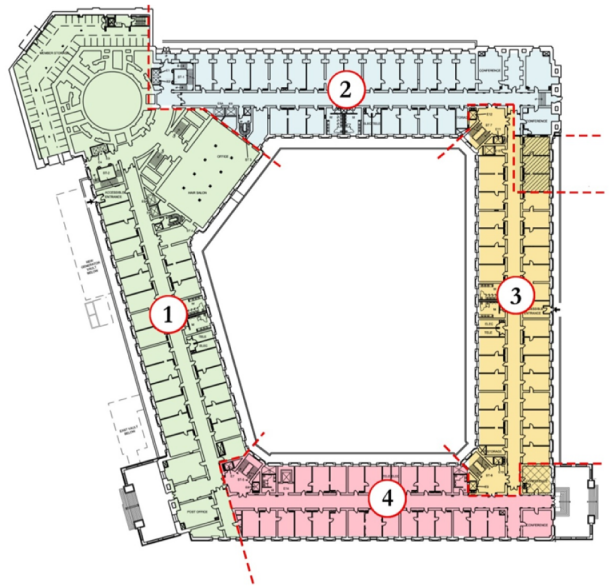
AOC intends to conduct construction in discrete phases affecting one section of the building at a time. The plan shown to the right illustrates the planned construction phasing.

Project scope includes:

- Demolition
- Repairs to heating and cooling, security, electrical, plumbing, and fire protection systems;
- Reconfiguration of interior spaces and restroom refurbishment
- Roof replacement
- Stone preservation

Project schedule:

- Five total phases (Phase 0, 1, 2, 3, 4)
- Phase 0 incorporates building utility work to relocate such items as electrical, plumbing, and heating and cooling equipment to prepare for the work in the four building sections
- Two years per building section phase (2017 – 2025)



Source: Architect of the Capitol.

Capitol Dome Restoration

The U.S. Capitol Dome, an important symbol of American democracy and an architectural icon, was constructed of cast iron more than 150 years ago. According to AOC, the dome has not undergone a complete restoration since 1960, and due to age and weather is now plagued by more than 1,000 cracks and deficiencies that are causing it to deteriorate. Figure 3 shows cracks at the exterior column base and deteriorating interior paint.

Figure 3: Damage to Capitol Dome, Outside Left, Inside Right (2013 Photographs)



Source:GAO.



Source: GAO.

The project is intended to stop deterioration in the dome's cast iron structure as well as to ensure the protection of the interior of the dome and rotunda. In the 1960 restoration, the dome was stripped of its paint so the ironwork could be repaired, primed with a rust inhibitor, and then repainted. As part of the current project, AOC is undertaking similar restorative work to include removing old paint, repairing the cast iron, and repainting.

The project has proceeded in phases as shown in table 2, with phase IIA restoration work currently in progress. In earlier phases, AOC completed interim painting, revalidated the project's design, and restored the base—or skirt—of the dome. To complete the project, AOC is seeking appropriations of about \$20 million for construction and other costs for phase IIC work in fiscal year 2015. As of February 2014, AOC estimated the total cost of the Capitol Dome restoration project at about \$125 million.

Table 2: Phases and Budget of the Capitol Dome’s Restoration Project, as of February 2014

Phase	Description	Status	Total cost (\$ Thousands)
IA	Interim painting 2002	Completed 01/03/2003	Not included
IB	Interim painting 2010	Completed 12/20/2010	2,500
IC	Skirt restoration	Completed 09/01/2012	19,959
Phase II	Design revalidation	Completed 12/12/2012	3,996
Phase IIA	Dome restoration exterior estimated 24-month duration	Contract Awarded 09/30/2013	58,070
Phase IIB	Dome restoration interior estimated 9-month duration	Option in phase IIA contract (fiscal year 2014 appropriations received, option not yet exercised)	15,400
Phase IIC	Dome restoration Rotunda estimated 1- month duration	Unfunded option in phase IIA contract (estimated to be awarded in fiscal year 2015)	20,220
Other Costs	Study, design, inspection, US Capitol Police overtime	Miscellaneous over phases	5,228
Total			125,373

Source: GAO analysis of AOC data.

Note: We focused our assessment on estimates for work currently in progress (phase IIA) or planned to be completed (phases IIB and IIC).

AOC's Policies and Guidance Conform to Leading Practices for Two Characteristics of Reliable Cost Estimates, but Fall Short in Two Others

As previously discussed, the *GAO Cost Estimating and Assessment Guide*¹² defines 12 leading practices related to four characteristics—*comprehensive, well documented, accurate, and credible*—that are important to developing high-quality, reliable estimates.¹³ Our analysis determined how well AOC met a characteristic based on our assessment of AOC's conformance to the leading practices related to that characteristic. We discuss characteristics using five rating categories—does not meet, minimally meets, partially meets, substantially meets, or fully meets.¹⁴ As shown in table 3, our analysis found that AOC's cost-estimating policies and guidance contribute to estimates that are *comprehensive* and *well documented* in that AOC fully meets most of the tasks that underlie the leading practices associated with these two characteristics. We found that AOC's cost-estimating policies and guidance partially met the *accuracy* characteristic and minimally met the *credible* characteristic based on their conformance to the leading practices associated with those characteristics. Table 3 also contains key examples of our rationale for our assessment of each leading practice and characteristic.

Table 3: GAO Summary Assessment of AOC Cost-Estimating Guidance and Policies

GAO assessment	Characteristic	Leading Practice	Key examples of rationale for assessment
●	Comprehensive	Develop the estimating plan	AOC has a formal process that develops the estimating plan, including describing responsible parties and defining specific tasks.
		Determine the estimating structure	The estimating structure follows a work breakdown structure (WBS) ^a that appears to be standard in the construction industry.
●	Well documented	Define estimate's purpose	AOC uses different types of cost estimates and has defined when each applies and what each entails.
		Define the program's characteristics ^b	AOC has formally defined program characteristics.
		Identify ground rules and assumptions	AOC points to supporting documents that, when developed, should contain ground rules and assumptions specific to a given project.
		Obtain the data	AOC guidance is specific about sources of data. These include commercially available construction cost databases as well as market and industry knowledge, staff knowledge, and historical data.

¹²[GAO-09-3SP](#).

¹³See Appendix I for the associated tasks within the 12 leading practices.

¹⁴See footnote 5.

GAO assessment	Characteristic	Leading Practice	Key examples of rationale for assessment
		Document the estimate	AOC's guidance explains how to document the estimate.
		Present estimate to management for approval	AOC's guidance requires management approval of estimates.
●	Accurate	Develop the point estimate ^c	AOC develops point estimates as projects progress through planning and design phases to support budget requests.
		Update the estimate to reflect actual costs/changes	AOC does not update estimates with actual costs as projects progress.
○	Credible	Compare the point estimate to an independent cost estimate (ICE) ^c	ICE's defined by AOC's estimating process have a limited degree of independence.
		Conduct a sensitivity analysis	AOC guidance discusses some sensitivity analysis, but it skips many steps identified by GAO in its leading practices.
		Conduct a risk and uncertainty analysis	AOC's guidance is to set aside a fixed amount for contingency. ^d This is not as beneficial as quantitative-risk and uncertainty analysis to assess the variability in the estimate and the level of confidence associated with the cost estimate.

Source: GAO analysis of AOC data.

- = Fully Meets: AOC provided complete evidence that satisfies the associated tasks of the leading practices
- = Substantially Meets: AOC provided evidence that satisfies a large portion of the associated tasks of the leading practices
- = Partially Meets: AOC provided evidence that satisfies about half of the associated tasks of the leading practices
- = Minimally Meets: AOC provided evidence that satisfies a small portion of the associated tasks of the leading practices
- = Does Not Meet: AOC provided no evidence that satisfies the associated tasks of the leading practices

^aA WBS deconstructs a program's end product into successive levels with smaller specific elements until the work is subdivided to a level suitable for management control. AOC requires use of the ASTM UNIFORMAT II structure, which is organized according to systems or assemblies that are common to most buildings, for estimates.

^bIn the context of this report, a program refers to a group of projects or functions associated with delivering a capital asset. For example, the Cannon House Office Building program refers to projects or functions—completed via contract or by AOC staff—for planning, designing, and constructing all phases of the renewal work and providing for ongoing operations and maintenance of the facility.

^cAs described in the GAO's *Cost Estimating and Assessment Guide*, developing the point estimate and comparing it to an independent cost estimate are separate parts of a single leading practice. For purposes of assessing the extent to which a cost estimate achieves the characteristics of a high-quality cost estimate, developing the point estimate contributes to accuracy, while comparing the point estimate to an independent cost estimate contributes to credibility.

^dAOC applies additional percentages to the items in the cost estimate for contingencies at a series of milestones in completing projects' design and construction documents as established by AOC policy. For example, early in the projects' design, AOC establishes a contingency range for design at 20 to 25 percent and construction at 5 to 20 percent. When the design is completed, the design contingency is removed.

AOC Conforms to the Leading Practices Associated with Comprehensive and Well Documented Cost Estimates

Comprehensive

In reference to the leading practices underlying the characteristics of a comprehensive cost estimate, we found that AOC

- has a formal process for developing estimating plans, and
- follows an estimating approach incorporating a work breakdown structure (WBS) that is widely used in the construction industry.¹⁵

In developing estimating plans, we found that AOC's policies and guidance that describe the project-planning process provide the framework for meeting this leading practice. In the planning stage, AOC project managers establish project scope and outline roles and responsibilities for planning, design, and construction stages. To facilitate these efforts, AOC project managers are to use particular documents. One document, the Project Development Form, provides a basis for preparing requirements studies that help to define scope and estimate costs. AOC then is to use this information in developing Project Management Plans that are to describe other key components of project delivery. These components include defining the strategy for providing design and construction services, identifying project team members, establishing a communications plan, and setting project controls such for managing project changes. AOC also considers cost reporting as a component of the project delivery process.¹⁶ For example, AOC typically requires its design contractors to provide cost reports at the same time incremental design submittals are made. Because AOC's project development process accounts for cost reporting, we determined that it

¹⁵A WBS deconstructs a program's end product into successive levels with smaller specific elements until the work is subdivided to a level suitable for management control. For estimates, AOC requires use of the ASTM UNIFORMAT II structure, which is organized according to systems or assemblies that are common to most buildings.

¹⁶AOC's policies and guidelines define cost reports that are relevant to various points of a project's development. Reports range from "exploratory cost assessments," conducted at a pre-planning stage, to a "construction cost estimate," based on completed and approved construction documents.

satisfies the intent of the leading practice encouraging use of a formal process for developing estimating plans.

Well Documented

With regard to leading practices related to producing well-documented estimates, we found that AOC

- requires formal definitions of program¹⁷ characteristics, such as the program's purpose;
- develops ground rules and assumptions from supporting documents;
- requires the use of cost data sources that are specific to the construction industry (i.e., obtain the data);
- requires documenting the estimate and supporting documents; and
- requires management approval of the cost estimate.

AOC fully meets the requirements of most of these leading practices.¹⁸ For example, AOC's policies and guidance for the project development process provide the structure to enable an adequate understanding of program characteristics—such as key design features, technical definitions, and the acquisition strategy—that will comprise the cost estimate. In addition, AOC guidance establishes requirements for use of industry-accepted cost-data sources and allows for application of staff knowledge and historical data in developing estimates.¹⁹ AOC guidance also provides for estimates to be documented to show important parameters, assumptions, descriptions, methods, and calculations used to derive the estimate. However, while AOC requires management approval of its cost estimates, it falls short of fully meeting the requirements of this leading practice. In particular, AOC's briefings do not include the level of information defined by our leading practice,

¹⁷In the context of this report, a program refers to a group of projects or functions associated with delivering a capital asset. For example, the Cannon House Office Building program refers to projects or functions—completed via contract or by AOC staff—for planning, designing, and constructing all phases of the renewal work and providing for ongoing operations and maintenance of the facility.

¹⁸We determined that AOC fully meets the well-documented characteristic even though it does not fully meet the requirements of the six underlying leading practices. Our assessment method weights each leading practice equally and bases the category-level assessment on the average score of underlying leading practices. Because the average score of all leading practices contributing to the well documented characteristic is at the fully meets level, we say that AOC fully meets the requirements of the well-documented characteristic.

¹⁹Industry sources include the R.S. Means Cost Database.

particularly information related to risks associated with the underlying data and methods. This is due, in part, to AOC's policies and guidance not requiring a risk and uncertainty analysis in developing estimates. We discuss this leading practice in the following section of this report.

AOC Partially and Minimally Conforms to the Leading Practices Associated with Accurate and Credible Cost Estimates, Respectively

We found that AOC policies and guidance do not require enough detail to suggest that resulting estimates would be accurate and credible.

Accurate

In reference to *accuracy*, we found that AOC's policies and guidance partially meet the respective underlying leading practices pertaining to this characteristic. According to AOC's policies and guidance, AOC is to develop estimates as projects progress through planning and design phases that are based on sufficiently detailed documentation of construction requirements. AOC is to then use these estimates to support budget requests for construction funding. However, AOC's guidance does not require that cost estimates be updated with actual costs during a project's construction phase—a leading practice. According to the *Cost Guide*, updating estimates to reflect actual costs as the project progresses allows agencies to review variances between planned and actual costs and provides insight as to how the project changed over time.

Credible

In reference to *credibility*, we found that AOC's policies and guidance minimally meet the underlying leading practices pertaining to this characteristic. For example, we found that AOC's guidance does not require

-
- following all steps for conducting a “sensitivity analysis”²⁰ and determining the estimate’s reasonableness, and
 - conducting a risk and uncertainty analysis.²¹

While AOC guidance does discuss conducting some sensitivity analysis, it skips many associated tasks of leading practices we identified, such as identifying key cost drivers, ground rules and assumptions for sensitivity testing, and evaluating the results to determine which drivers most affect the cost estimate. Similarly, while AOC guidance provides that contingencies be added to estimates to account for risk and uncertainty, AOC’s guidance does not provide documented reasons explaining how the actual budgeted amounts for unforeseen costs were developed.²² AOC officials told us that while their policies and guidance do not require sensitivity or “quantitative-risk and uncertainty analyses,” they perform such assessments qualitatively to establish budget contingency. However, the leading practice to determine whether a program is realistically budgeted is to perform a quantitative-risk and uncertainty analysis,²³ so that the probability associated with achieving its point estimate can be determined. The results of a quantitative-risk and uncertainty analysis—the range of costs around a point estimate—can be useful to decision makers because it conveys the confidence level in

²⁰According to the *Cost Guide*, a “sensitivity analysis” addresses some of the estimating uncertainty by testing discrete cases of assumptions and other factors that could change. By examining each assumption or factor independently, while holding all others constant, the cost estimator can evaluate the results to discover which assumptions or factors most influence the estimate. A sensitivity analysis also requires estimating the high and low uncertainty ranges for significant cost driver input factors. To determine what the key cost drivers are, a cost estimator needs to determine the percentage of total cost that each cost element represents. The major contributing variables within the highest percentage cost elements are the key cost drivers that should be varied in a sensitivity analysis.

²¹“Quantitative-risk and uncertainty analysis” provide a way to assess the variability in the estimate. Using this type of analysis, a cost estimator can model such effects as schedules slipping, missions changing, and proposed solutions not meeting user needs, allowing for a known range of potential costs.

²²AOC applies additional percentages to the items in the cost estimate for contingencies at a series of milestones in completing the design and construction documents of the project as established by AOC policy. For example, early in the projects’ design, AOC establishes a contingency for design at 20 to 25 percent and construction at 5 to 20 percent. When the design is completed, the design contingency is removed.

²³The analysis produces a cumulative probability distribution, more commonly known as an S curve—usually derived from a simulation such as Monte Carlo—and is useful in portraying the uncertainty implications of various cost estimates.

achieving the most likely cost and informs them about cost, schedule, and technical risks.²⁴ Not having an understanding of an estimate's confidence level limits AOC's ability to determine the appropriate level of contingency that is needed to address risks and uncertainty for a particular project and could lead AOC to ineffectively allocate resources across competing projects if contingency levels are either overstated or understated. In addition, absent information on estimates' confidence levels, Congress will not have critical information for making well-informed funding decisions.

In addition, pertaining to the leading practice of developing a point estimate and comparing it to an independent cost estimate (ICE)—which affects both *accurate* and *credible* characteristics—we found that the independent estimates defined by AOC's estimating process have a limited degree of independence and focus solely on proposed contractor costs rather than on the entire cost estimate, including both government and contractor efforts. According to our leading practices, an ICE, conducted by an organization outside the program office, provides an objective and unbiased assessment of whether the agency's program estimate can be achieved. However, because AOC's project management and cost-estimating functions are performed within the same organizational group, the estimates could potentially be influenced by AOC's project managers and therefore could be susceptible to bias.

Because of the weaknesses in AOC's policies and guidance pertaining to two of the four characteristics that are important to developing high-quality, reliable estimates, the project cost estimates that AOC produces may not always be reliable. Without reliable cost estimates, AOC's projects risk experiencing cost overruns or budget surpluses, missed deadlines, and performance shortfalls. Furthermore, potential limitations in the reliability of its estimates may impair Congress's ability to make well-informed funding decisions and affect how AOC allocates resources across competing projects in its capital program.

²⁴A "point estimate" is the most likely value for the cost estimate, given the underlying data. The "level of confidence for the point estimate" is the probability that the point estimate will actually be met. For example, if the confidence level for a point estimate is 80 percent, there is an 80 percent chance that the final cost will be at or below the point estimate and a 20 percent chance that costs will exceed the point estimate.

Strengths and Weaknesses in AOC's Policies and Guidance Are Reflected in the Cannon Building and Capitol Dome Projects

In comparing the Cannon Office Building's renewal and Capitol Dome's restoration cost estimates to GAO's leading practices, we found strengths and weaknesses that generally correspond to our assessment of AOC's overall policies and guidance for developing cost estimates.²⁵ We initially determined that both estimates were comprehensive while lacking, to a varying extent, in their *documentation, accuracy, and credibility*.²⁶ Following our initial determination, AOC provided further documentation that resulted in improvements to each estimate's assessment. Our final assessment found that

- the Cannon Building renewal estimate to be substantially *comprehensive, well documented, and accurate* while lacking in elements affecting its *credibility*, and
- the Capitol Dome restoration estimate to be substantially *comprehensive and well documented* while lacking in areas pertaining to *accuracy and credibility*.

In aggregate, because of weaknesses pertaining to characteristics that are important to the development of high-quality, reliable estimates, AOC's cost estimates for the Cannon Building's renewal and Capitol Dome's restoration may not be fully reliable.²⁷ Appendix III provides additional details on our comparison of these two cost estimates to our leading practices.

Cannon Building's Renewal Estimate

In reference to the *comprehensive* characteristic, we found that the estimate substantially met the underlying leading practices.²⁸ In particular, the estimate uses a WBS²⁹ that is standard in the construction industry

²⁵The strengths and weakness in the Cannon Building' renewal and Capitol Dome's restoration estimates are generally consistent with the strengths and weaknesses we found in reviewing other agencies' estimates. Estimates that we have reviewed include those from the departments of Agriculture, Commerce, Defense, Energy, Homeland Security, Transportation, and Veterans Affairs; the Internal Revenue Service; and the Missile Defense Agency.

²⁶Our initial assessments were based upon documentation provided by AOC over a period of 3 months from October to December 2013.

²⁷While our review of these projects' cost estimates provides key insights and illustrates products of AOC's cost-estimating methodology, the results of our review cannot be generalizable to the universe of all AOC project cost estimates.

²⁸Appendix III provides additional information on our assessment of these estimates compared to the characteristics of high-quality, reliable estimates.

²⁹See footnote 15.

and allows for tracking of cost and schedule performance by defined elements of work. In addition, AOC conducted a life-cycle-cost analysis of the heating and cooling system alternatives it considered to include analyzing their energy consumption for the purpose of comparing operational costs. However, the estimate did not fully meet the characteristic as it did not include full life-cycle costs, from inception through design, construction, operation, and maintenance. Without a life-cycle cost analysis that captures the total cost of the project, AOC cannot evaluate design alternatives on a total-cost basis.

In terms of being *well documented*, we found that the estimate substantially met associated leading practices. In general, the information provided by AOC describes how the estimate was built up from engineering drawings, specifications, and design documents. In addition, there was evidence of documented management approval. However, the documentation AOC provided did not contain source data, such as from contractor bids or cost estimating databases. While AOC officials said they could obtain this information for our review, to the extent that it was available,³⁰ our leading practices indicate that an estimate's documentation should be detailed enough so that the derivation of each cost element can be traced to all sources allowing for the estimate to be easily replicated and updated. Because AOC could not readily provide the actual source data for the estimate, we determined that it did not fully meet the requirements of this characteristic.

For the *accuracy* characteristic, we found the estimate substantially met leading practices. AOC's acquisition approach to the building's renewal involves its contracting with an architect, construction manager, and construction contractor, each of whom produced separate estimates. These estimates have a limited degree of independence because they were conducted for the same program office and focus only on the proposed contractor cost. However, this array of estimates has enabled AOC to make comparisons among them, determine similarities and

³⁰AOC indicated that source data for one of the estimates we reviewed derives from a proprietary system maintained by its contractor. As such, AOC said that the source information contained in this system could not be provided to us.

differences, and develop a reasonably accurate assessment of estimated costs.³¹

For the *credibility* characteristic, we found the estimate partially met leading practices. During the course of our review, AOC conducted a risk and uncertainty analysis in accordance with a key leading practice for this characteristic.³² However, we found several issues affecting the quality of the analysis that AOC provided to us. For example, AOC's analysis concluded that the Cannon Building's renewal estimate had a confidence level that exceeded 90 percent—meaning there is a greater than a 90 percent probability that actual costs will be equal to or less than AOC's estimate—which may be unreasonably high.³³ However, an AOC official said that the agency will be reconsidering the confidence level once the design progresses further. In addition, we found that the method AOC used to model the project's risks it identified (1) resulted in an unusually narrow range of estimated costs across the confidence intervals and (2) provides managers limited ability to understand the effects of individual risks.³⁴ Because AOC aggregated risks for the purposes of its analysis as opposed to modeling them separately, AOC cannot identify relationships between risk elements and determine which risks have the greatest influence on project costs. As a result, AOC is limited in its ability to manage the risks. In addition, modeling the aggregated risks likely contributes to the overly narrow range of estimated costs over the

³¹We did not assess the cost of Cannon Building's renewal project estimate for one of the leading practices for *accuracy*. As construction has not begun on the project, AOC has not had the opportunity to update the estimate with actual costs.

³²While AOC's policies and guidance for developing cost estimates do not require conducting a risk and uncertainty analysis, AOC officials determined during the course of our review that it would be beneficial to perform a quantitative-risk and uncertainty analysis on the cost estimate for the Cannon Building's renewal. AOC provided a draft of its analysis in January 2014, and our report discusses our assessment of AOC's draft analysis.

³³A project funded to an unreasonably high confidence level may be over-budgeted. While our leading practices do not specify target confidence levels, experts we consulted in developing our leading practices agreed that program cost estimates should be budgeted to at least the 55 percent confidence level and potentially as high as 80 percent.

³⁴AOC identified 60 risks to the project in conducting its risk and uncertainty analysis and estimated that their potential cost impact was \$161 million. AOC used the aggregated risks in creating a distribution of construction costs using a Monte Carlo simulation.

Capitol Dome's Restoration Estimate

confidence levels, which implies that AOC's analysis overstates the effect of the risks.³⁵

In reference to the comprehensive characteristic, we found that the estimate substantially met leading practices. In particular, the estimate uses an industry-standard WBS format and contains sufficient detail of the technical characteristics of the project. However, the estimate did not fully meet leading practices, in part because we did not find a consolidated list of ground rules and assumptions or descriptions of how these affected the estimate. Contract documents provide indications of ground rules and assumptions affecting the project. For example, contract specifications and drawings for the recently-awarded phase II work describe assumptions pertaining to availability of funding for contract options and accessibility of the site during the workday. However, we could not determine if these represented a comprehensive assessment of all ground rules and assumptions. According to the *Cost Guide*, because ground rules and assumptions can significantly affect cost and introduce risk, it is important that they are clearly documented in the estimate to enable areas of potential risk to be identified and resolved.

For the *well documented* characteristic, we determined the estimate as having substantially met leading practices. We found, for example that cost elements from the estimate can be compared to information in the drawings and specifications that define the contract for the phase II restoration. This linkage enables a good understanding of key characteristics of the estimate. In addition, AOC attested that the estimate had been briefed to and approved by management. However, because records describing briefings of the estimate to management are not well documented, it is difficult to trace management's recommendations for changes, feedback, and key decisions affecting the project. While AOC officials told us that its project staff and management communicate routinely as part of their normal business functions, documenting management briefings is important because some key personnel have changed over the life of the Capitol Dome restoration project, which

³⁵AOC's analysis shows, for example, the difference between the estimate at the 50 percent confidence level and 90 percent confidence level is about \$25 million, approximately 3 percent of the total estimate. Modeling the risks individually would likely have resulted in a greater spread between the 50 and 90 percent confidence levels and given a more accurate indication of expected costs and of which risks were most significant.

originated more than 15 years ago. By not having well documented records of management briefings over the life of the project, AOC risks loss of continuity in its oversight.

Considering the *accuracy* characteristic, we determined that the estimate partially met leading practices. We found, for example, that the estimating software and database used to construct the estimate included standard information, such as costs for labor, materials, and equipment. However, AOC did not consider the actual cost of previously completed restoration phases in updates to its estimate for the phase II work. While AOC used information on the price it paid for certain items in the phase I restoration work that are also part of the phase II project, it did not determine the contractor's actual cost to perform the work. AOC officials said that having information on actual contractor costs for items may be of limited usefulness because market conditions and other factors determine what contractors bid and AOC ultimately pays. However, not having information on actual costs makes it difficult for AOC to assess the difference between the price it paid and its contractors' costs to determine the estimate's reasonableness.

For the *credibility* characteristic, we determined that the estimate minimally met leading practices. We found, in contrast to the approach it took in developing the Cannon Building renewal estimate, that AOC did not conduct a risk and uncertainty analysis of the Capitol Dome restoration estimate. While AOC officials told us they have not conducted a quantitative-risk and uncertainty analysis of the estimate, they said they have taken steps to qualitatively assess and mitigate project risks. For example, AOC structured the phase II contract solicitation to have contractors include a base bid (phase IIA) and pre-priced options for later stages (phases IIB and IIC) of the work. According to AOC officials, by structuring the contract this way, AOC is protected from price escalations affecting the future phases. In addition, AOC established unit prices and quantity allowances for some restoration tasks that are of indefinite quantity, such as repairing cracks. According to AOC officials, this will help to control project costs because, while their quantity estimates may be imprecise, knowing the unit prices associated with the work should mitigate some cost risk. While these actions are encouraging, they are not documented within the context of a quantitative-risk and uncertainty analysis. As a result, we do not know how these actions relate to other risk mitigation efforts that may have been considered and why AOC chose these actions over other efforts. Moreover, not having a quantitative-risk and uncertainty analysis precludes establishing a level of confidence associated with achieving the estimated cost and limits AOC

management's ability to determine an appropriate level of contingency reserves that may be necessary to address risks that AOC has identified.

Conclusions

AOC project's cost-estimating guidance policy and two resulting project estimates that we reviewed may not be fully reliable because they incorporated some, but not all, leading practices in cost estimating. Because AOC's project cost estimates inform Congress's funding decisions and affect AOC's ability to effectively allocate resources across competing projects in its capital program, there is a risk that funding decisions and resource allocations could be made based on information that is not reliable. We recognize that incorporating GAO's cost-estimating best practices into AOC's cost-estimating policy and guidance may involve additional costs—such as for conducting a risk and uncertainty analysis for projects and conveying the confidence level of the estimate to Congress and AOC managers. However, without investing in these practices, Congress risks making funding decisions and AOC management risks making resource allocation decisions without the benefit that a robust analysis of levels of risk, uncertainty, and confidence provide decision makers.

Recommendations

To improve the Architect of the Capitol's project-cost-estimating process, enhance the transparency of its related process, and allow for more informed decision making related to projects' costs, we recommend that the Architect of the Capitol take the following two actions, to the extent that the benefits exceed the costs:

- incorporate leading practices we identified as lacking for cost estimating in the AOC's cost-estimating guidance and policies, and
- for ongoing and future projects, submit the confidence level derived from risk and uncertainty analyses along with budget documentation to appropriate congressional decision makers, so that Congress is aware of the range of likely costs and AOC's associated confidence levels.

Agency Comments and Our Evaluation

We provided a draft of this report to the Architect of the Capitol for review and comment. AOC agreed with our recommendations and provided us with additional context and information on specific actions that the AOC has taken or intends to take to more fully address our recommendations. For example, AOC said that it planned to revise its policies and procedures to require quantitative-risk and uncertainty analysis be done, as specified in the *Cost Guide*, for high-dollar-value projects prior to

requesting construction funding. In addition, AOC said that it would explore the most effective approach for communicating to congressional decision makers the confidence level derived from risk and uncertainty analyses along with budget documentation. We made no changes to our draft based upon AOC's comments. AOC's comments are reprinted in appendix IV, followed by our response to AOC's detailed comments.

We are sending copies of this report to appropriate congressional committees and the Architect of the Capitol. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or stjamesl@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix V.



Lorelei St. James
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Appendix I: The Leading Practices for Developing High-Quality Cost Estimates and Associated Tasks

Step	Leading practice	Associated task
1	Define estimate's purpose	<ul style="list-style-type: none"> Determine estimate's purpose, required level of detail, and overall scope; Determine who will receive the estimate.
2	Develop estimating plan	<ul style="list-style-type: none"> Determine the cost-estimating team and develop its master schedule; Determine who will do the independent cost estimate; Outline the cost-estimating approach; Develop the estimate's timeline.
3	Define program characteristics	<ul style="list-style-type: none"> In a technical baseline-description document, identify the program's purpose and its system and performance characteristics and all system configurations; Any technology implications; Its program acquisition schedule and acquisition strategy; Its relationship to other existing systems, including predecessor or similar legacy systems; Support (manpower, training, etc.) and security needs and risk items; System quantities for development, test, and production; Deployment and maintenance plans.
4	Determine estimating structure	<ul style="list-style-type: none"> Define a work breakdown structure (WBS) and describe each element in a WBS dictionary (a major automated-information system may have only a cost element structure); Choose the best estimating method for each WBS element; Identify potential cross-checks for likely cost and schedule drivers; Develop a cost-estimating checklist.
5	Identify ground rules and assumptions	<ul style="list-style-type: none"> Clearly define what the estimate includes and excludes; Identify global and program-specific assumptions, such as the estimate's base year, including time phasing and life cycle; Identify program schedule information by phase and program acquisition strategy; Identify any schedule or budget constraints, inflation assumptions, and travel costs; Specify equipment the government is to furnish as well as the use of existing facilities or new modification or development; Identify prime contractor and major subcontractors; Determine technology refresh cycles, technology assumptions, and new technology to be developed; Define commonality with legacy systems and assumed heritage savings; Describe effects of new ways of doing business.

**Appendix I: The Leading Practices for
Developing High-Quality Cost Estimates and
Associated Tasks**

Step	Leading practice	Associated task
6	Obtain data	<ul style="list-style-type: none"> • Create a data collection plan with emphasis on collecting current and relevant technical, programmatic, cost, and risk data; • Investigate possible data sources; • Collect data and normalize them for cost accounting, inflation, learning, and quantity adjustments; • Analyze the data for cost drivers, trends, and outliers and compare results against rules of thumb and standard factors derived from historical data; • Interview data sources and document all pertinent information, including an assessment of data reliability and accuracy; • Store data for future estimates.
7	Develop point estimate and compare it to an independent cost estimate	<ul style="list-style-type: none"> • Develop the cost model, estimating each WBS element, using the best methodology from the data collected, and including all estimating assumptions; • Express costs in constant year dollars; • Time-phase the results by spreading costs in the years they are expected to occur, based on the program schedule; • Sum the WBS elements to develop the overall point estimate; • Validate the estimate by looking for errors like double counting and omitted costs; • Compare estimate against the independent cost estimate and examine where and why there are differences; • Perform cross-checks on cost drivers to see if results are similar; • Update the model as more data become available or as changes occur and compare results against previous estimates.
8	Conduct sensitivity analysis	<ul style="list-style-type: none"> • Test the sensitivity of cost elements to changes in estimating input values and key assumptions; • Identify effects on the overall estimate of changing the program schedule or quantities; • Determine which assumptions are key cost drivers and which cost elements are affected most by changes.
9	Conduct risk and uncertainty analysis	<ul style="list-style-type: none"> • Determine and discuss with technical experts the level of cost, schedule, and technical risk associated with each WBS element; • Analyze each risk for its severity and probability; • Develop minimum, most likely, and maximum ranges for each risk element; • Determine type of risk distributions and reason for their use; • Ensure that risks are correlated; • Use an acceptable statistical analysis method (e.g., Monte Carlo simulation) to develop a confidence interval around the point estimate; • Identify the confidence level of the point estimate; • Identify the amount of contingency funding and add this to the point estimate to determine the risk-adjusted cost estimate; • Recommend that the project or program office develop a risk management plan to track and mitigate risks.

**Appendix I: The Leading Practices for
Developing High-Quality Cost Estimates and
Associated Tasks**

Step	Leading practice	Associated task
10	Document the estimate	<ul style="list-style-type: none"> • Document all steps used to develop the estimate so that a cost analyst unfamiliar with the program can recreate it quickly and produce the same result; • Document the purpose of the estimate, the team that prepared it, and who approved the estimate and on what date; • Describe the program, its schedule, and the technical baseline used to create the estimate; • Present the program’s time-phased life-cycle cost; • Discuss all ground rules and assumptions; • Include auditable and traceable data sources for each cost element and document for all data sources how the data were normalized; • Describe in detail the estimating methodology and rationale used to derive each WBS element’s cost (prefer more detail over less); • Describe the results of the risk, uncertainty, and sensitivity analyses and whether any contingency funds were identified; • Document how the estimate compares to the funding profile; • Track how this estimate compares to any previous estimates.
11	Present estimate to management for approval	<ul style="list-style-type: none"> • Develop a briefing that presents the documented life-cycle cost estimate; • Include an explanation of the technical and programmatic baseline and any uncertainties; • Compare the estimate to an independent cost estimate (ICE) and explain any differences; • Compare the estimate (life-cycle cost estimate (LCCE)) or independent cost estimate to the budget with enough detail to easily defend it by showing how it is accurate, complete, and high in quality; • Focus in a logical manner on the largest cost elements and cost drivers; • Make the content clear and complete so that those who are unfamiliar with it can easily comprehend the competence that underlies the estimate results; • Make backup slides available for more probing questions; • Act on and document feedback from management; • Request acceptance of the estimate.
12	Update the estimate to reflect actual costs and changes	<ul style="list-style-type: none"> • Update the estimate to reflect changes in technical or program assumptions or keep it current as the program passes through new phases or milestones; • Replace estimates with EVM, and independent estimate at completion (EAC) from the integrated EVM system; • Report progress on meeting cost and schedule estimates; • Perform a post mortem and document lessons learned for elements whose actual costs or schedules differ from the estimate; • Document all changes to the program and how they affect the cost estimate.

Source: GAO, DHS, DOD, DOE, NASA, SCEA, and industry.

Appendix II: Objectives, Scope, and Methodology

The House Appropriations Committee report accompanying the fiscal year 2014 Legislative Branch Appropriations Bill (H.R. 2792) mandated that we review the Architect of the Capitol's (AOC) cost estimating methodology to ensure that AOC is accounting for all of the variables that should contribute to project cost estimates.¹ This report addresses the extent to which AOC's policies and guidance for developing cost estimates conform to leading practices identified in GAO's *Cost Estimating and Assessment Guide*² and provide a reliable basis to support funding and capital program decisions. This report also examines whether the estimates for the Capitol Dome and the Cannon Building projects reflect leading practices.

To determine the extent to which AOC's policies and guidance comply with leading practices for cost estimating and provide a reliable basis to support funding and program decisions, we compared AOC's documents to leading practices set forth in GAO's *Cost Estimating and Assessment Guide*.³ The *Cost Guide* identifies 12 leading practices that represent work across the federal government and are the basis for a high-quality, reliable cost estimate. An estimate created using the leading practices exhibits four broad characteristics: it is accurate, well documented, credible, and comprehensive. That is, each characteristic is associated with a specific set of leading practices. In turn, each leading practice is made up of a number of specific tasks. (See app, I for a listing of the tasks that make up each of the 12 leading practices.) When the tasks associated with the leading practices that define a characteristic are mostly or completely satisfied, we consider the characteristic to be "substantially" or "fully" met. When all four characteristics are at least

¹H.R. Rep. No. 113-173, at 11 (2013).

²GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, [GAO-09-3SP](#) (Washington, D.C.: March 2009).

³[GAO-09-3SP](#).

“substantially met”—we consider a cost estimate to be reliable.⁴ We shared our analysis with AOC officials to review, comment, and provide additional information, and we adjusted our analysis where appropriate.

In reference to our examination of the estimates for the Capitol Dome and Cannon Building projects, we selected these projects based on their significance to the Capitol Complex, comparatively high costs, and public visibility. In addition, our review of the Cannon Building estimate is responsive to a mandate in the House Appropriations Committee report accompanying the fiscal year 2010 Legislative Branch Appropriations Bill (H.R. 2918) requiring us to monitor the progress of the project.⁵ We selected versions of the estimates to review that had the most complete information for our assessments. We assessed the reliability of data used in developing the estimates and found them to be sufficiently reliable for the purposes of this report. For example, while some source data were unavailable to us, we were able to assess AOC’s process for building its estimates with the data and check for errors. We also interviewed AOC’s staff and its technical consultant about these projects and observed existing conditions at the Cannon Building and Capitol Dome. While our review of these projects’ cost estimates provides key insights and illustrates products of AOC’s cost-estimating policies and guidance, the results of our review should not be used to make generalizations about all AOC project-cost estimates. We shared our analysis with AOC officials to review, comment, and provide additional information, and we adjusted our analysis where appropriate.

We conducted our work from September 2013 to March 2014 in accordance with all sections of GAO’s Quality Assurance Framework that are relevant to our objectives. The framework requires that we plan and

⁴We established five descriptions for our assessments of leading practices and cost estimate characteristics: Fully Meets, Substantially Meets, Partially Meets, Minimally Meets, and Does Not Meet. We consider a leading practice to be fully met when the associated tasks are completely satisfied; substantially met when a large portion of the associated tasks are satisfied; partially met when about half of the associated tasks are satisfied; minimally met when a small portion of the associated tasks are satisfied; and not met when none of the associated tasks are satisfied. Our assessment method weights each leading practice equally and bases the assessment of each characteristic on the average score of underlying leading practices. We assign each description a numerical value (5 for Fully Meets to 1 for Does Not Meet) and round scores to the higher numerical value (i.e. a score of 4.5 would round up to 5).

⁵H. R. Rep. No. 111-160, at 21 (2009).

perform the engagement to obtain sufficient and appropriate evidence to meet our stated objectives and to discuss any limitations in our work. We believe that the information and data obtained, and the analysis conducted, provide a reasonable basis for any findings and conclusions in this product.

Appendix III: GAO's Summary Assessments of AOC's Project Cost Estimates for the Cannon Building's Renewal and Capitol Dome's Restoration

GAO assessment	Estimating leading practice characteristic and rationale for assessment
	Comprehensive
	<p>The cost estimate should include both government and contractor costs of the program over its full life cycle, from inception of the program through design, development, deployment, operation and maintenance, to retirement of the program. It should also completely define the program, reflect the current schedule, and be technically reasonable. Comprehensive cost estimates should be structured in sufficient detail to ensure that cost elements are neither omitted nor double counted. Specifically, the cost estimate should be based on a product-oriented work breakdown structure (WBS) that allows a program to track cost and schedule by defined deliverables, such as hardware or software components. Finally, where information is limited and judgments must be made, the cost estimate should document all cost-influencing ground rules and assumptions.</p>
●	<p>The Cannon Building cost estimate did not include all life cycle costs as AOC guidance did not require these life cycle costs to be identified. The estimate tracked well with the work required, as it had a WBS structure consistent with this type of effort, and clearly laid out and appeared to update ground rules and assumptions based on evolving understanding of the scope of work.</p>
●	<p>The Capitol Dome cost estimate covers the construction phase of the dome's restoration. The cost estimate relies on specifications and drawings that exist in separate files. The cost estimate uses a standard WBS structure but does not include the underlying data. AOC submitted an extract of the data for our review. While the specifications include ground rules and assumptions, the cost estimate does not specify them.</p>
	Well documented
	<p>A good cost estimate—while taking the form of a single number—is supported by detailed documentation that describes how it was derived and how the expected funding will be spent in order to achieve a given objective. Therefore, the documentation should capture in writing such things as the source data used, the calculations performed and their results, and the estimating methodology used to derive each WBS element's cost. Moreover, this information should be captured in such a way that the data used to derive the estimate can be traced back to, and verified against, their sources so that the estimate can be easily replicated and updated. The documentation should also discuss the technical baseline description and how the data were normalized. Finally, the documentation should include evidence that the cost estimate was reviewed and accepted by management.</p>
●	<p>The Cannon Building cost estimate documentation did not provide source data. It did provide a reasonable explanation for how the cost estimates were prepared, what type of data were used, and the basic estimating methodologies indicating some step by step processes. The documentation provided consisted of tables of unit values, quantities, and extended values. While extended costs were identified, it was difficult to follow the roll-up of these costs. Without a copy of or access to the cost model, we were unable to verify the accuracy of escalation calculations and we could not trace all of the logic from the source data to the resulting estimate. The calculations and changes to the baseline were not well documented but subsequent data and explanations highlighted the process for the changes. Additionally, soft costs and contingencies, comprising a substantial portion of total program costs, were only superficially addressed. There was evidence of management approval of the estimate.</p>
●	<p>The Capitol Dome cost estimate captures all source documents used. The cost estimate relies on a WBS and shows how the calculations were performed. A cost analyst unfamiliar with the program could develop the cost estimate, although in places it is not clear. The cost estimate has a brief reference to the source documents used. Costs are presented in constant-year and then-year dollars.</p>

**Appendix III: GAO's Summary Assessments of
AOC's Project Cost Estimates for the Cannon
Building's Renewal and Capitol Dome's
Restoration**

GAO assessment Estimating leading practice characteristic and rationale for assessment

Accurate

The cost estimate should provide for results that are unbiased, and it should not be overly conservative or optimistic. An estimate is accurate when it is based on an assessment of most likely costs, adjusted properly for inflation, and contains few, if any, minor mistakes. In addition, a cost estimate should be updated regularly to reflect significant changes in the program—such as when schedules or other assumptions change—and actual costs, so that it is always reflecting current status. During the update process, variances between planned and actual costs should be documented, explained, and reviewed. Among other things, the estimate should be grounded in a historical record of cost estimating and actual experiences on other comparable programs.

● The Cannon Building cost estimate included an uncertainty analysis indicating what confidence level the budget fell within, which was greater than 90 percent. Additionally, in the absence of having the cost model used to prepare the estimate, we were only able to validate the accuracy of a very small sample of WBS elements. Furthermore, while the estimate documentation identified inflation adjustments, because of missing calculation and conversion factors, we were unable to determine if the estimate has been adjusted properly for inflation. However, the documentation did provide a discussion of what and how the inflation adjustments were applied.

● The Capitol Dome cost estimate did not include a risk and uncertainty analysis indicating what confidence level for the estimate the budget was set at. The estimate is shown in constant-year and then-year dollars using indices for inflation. The indices used to adjust for inflation appear to be out-of-date. The estimate has few errors. AOC updated its cost estimate prior to beginning the project, but once the project began, AOC did not update the estimate. AOC did not document variances between planned and actual costs. AOC relied on historical records and on an industry database to support its estimate. The estimate uses an engineering build-up throughout, which appears appropriate for this project.

Credible

The cost estimate should discuss any limitations of the analysis because of uncertainty or biases surrounding data or assumptions. Major assumptions should be varied, and other outcomes recomputed to determine how sensitive they are to changes in the assumptions. Risk and uncertainty analysis should be performed to determine the level of risk associated with the estimate. Further, the estimate's cost drivers should be crosschecked, and an independent cost estimate conducted by a group outside the acquiring organization should be developed to determine whether other estimating methods produce similar results.

● The Cannon Building cost estimate includes analyses of sensitivity, risk, and uncertainty. However, the sensitivity analysis was performed after the fact and was not used to inform the budget or provided for management consideration of risk prior to project start. AOC's risk and uncertainty analysis indicates that the budget for the project is set above the 90% confidence level, which may be unreasonably high. AOC has received multiple estimates from different sources (architect, construction manager, pre-construction contractor) as a cross-check for reasonableness. While these estimates are not necessarily outside the AOC program office's influence, they do appear to represent independent estimates based on each company's interpretation of the project's requirements and helped to validate the reliability of the estimates.

● The Capitol Dome cost estimate does not include a sensitivity, risk, and uncertainty analysis. AOC did not provide documented reasons explaining how the actual budgeted contingency amounts for unforeseen costs were developed. To mitigate risk, AOC negotiated unit costs to account for uncertainties in effort, such as the number of inches of stitching that would be needed to repair cracks. AOC does not appear to cross-check major cost elements, but AOC requested and obtained an independent cost estimate. AOC subsequently compared the point estimate and the independent cost estimate, and the two numbers were a close match.

Source: GAO analysis of AOC documents.

- = Fully Meets: AOC provided complete evidence that satisfies the associated tasks of the leading practices
- = Substantially Meets: AOC provided evidence that satisfies a large portion of the associated tasks of the leading practices
- = Partially Meets: AOC provided evidence that satisfies about half of the associated tasks of the leading practices

**Appendix III: GAO's Summary Assessments of
AOC's Project Cost Estimates for the Cannon
Building's Renewal and Capitol Dome's
Restoration**

◐=Minimally Meets: AOC provided evidence that satisfies a small portion of the associated tasks of the leading practices

○= Does Not Meet: AOC provided no evidence that satisfies the associated tasks of the leading practices

Appendix IV: Comments from the Architect of the Capitol

Note: GAO's comments supplementing those in the report's text appear at the end of this appendix.



Architect of the Capitol
U.S. Capitol, Room SB-15
Washington, DC 20515
202.228.1793
www.aoc.gov

March 14, 2014

Ms. Lorelei St. James
Director, Physical Infrastructure Issues
U.S. Government Accountability Office
Washington, D.C. 20548

Dear Ms. St. James:

We are pleased to have the opportunity to comment on your draft report to House and Senate Committees on Appropriations regarding our construction project cost estimating process. We also are appreciative of your staff's willingness to explain your cost estimating guide as well as your recognition that given the varying nature and size of our projects, a cost-benefit approach is appropriate for deciding which steps in the guide should be applied.

The Architect of the Capitol (AOC) has a systematic, thorough, and independent cost estimating process that we believe produces reliable estimates, and that our cost estimates for the Capitol Dome Restoration and Cannon Building Renewal projects are reliable as well. We appreciate that your draft report clearly notes that while your review of the Dome Restoration and Cannon Building Renewal projects' cost estimates provided key insights and illustrated "recent products of AOC's cost estimating policies and guidance," the results of your review "should not be used to make generalizations about all AOC project costs estimates." At the same time, we concur that incorporating leading practices you recommended in a cost-beneficial manner may make our cost estimates stronger as well as provide additional precision when setting contingency amounts. The strengths of our estimating process, as well as the steps we have taken or plan to take to implement your recommendations are summarized below.

Estimating Process Produces Reliable Results

The AOC has a well-structured, detailed, and robust cost estimating process, carried out by skilled and experienced staff and contractors, that provides reliable cost estimates used to formulate our annual budget requests, and in particular, our Line Item Construction Projects. As your draft report establishes, our cost estimating process incorporates many leading practices in whole or in part. In addition, we use best practices from a number of industry leaders and other federal agencies to ensure that appropriated dollars are invested in Congressional facilities wisely and effectively. In those instances in which our process does not follow leading practices to the letter, it generally addresses the leading practice in a meaningful manner. For example, although the guide calls for quantitative sensitivity and risk and uncertainty analyses, we perform these qualitatively in a way that assists us in identifying risks and uncertainties and setting contingencies as well as effectively

managing risks during construction. In addition, our cost estimates are not produced by the organization benefiting from the project. Instead, they are developed by contractors who are overseen by an organization separate from the benefiting organization, and are rigorously reviewed by a group separate from the project team and benefiting jurisdiction. When appropriate, we obtain a second estimate from a different contractor. Cost reports are prepared, reviewed, and approved by management. In many instances, management briefings occur and estimates are accepted. However, we recognize the need to improve the level of documentation kept as a result of these briefings, and other process steps to meet leading practices.

Enhancing the AOC's Cost Estimating Process

The vast majority of the AOC's work addresses necessary repairs and maintenance to Congressional facilities or historic preservation projects as opposed to new construction. Many of these projects are not high dollar projects such as those exemplified in your guide. Consequently, it would not be practical or cost effective to follow the Government Accountability Office's (GAO's) guide to the letter. We are pleased that you took costs and benefits into consideration in developing your recommendations. We have taken, or plan to take, the following actions to modify our cost estimating process to more fully address practices described in GAO's guide that will be cost effective and add value to our estimates.

- **Conduct sensitivity and risk and uncertainty analyses.** We currently perform these analyses qualitatively, but will revise our policies and guidance to require that they be done quantitatively as specified in your guide for high dollar value projects prior to requesting construction funding. We have completed a quantitative sensitivity and risk and uncertainty analyses for the Cannon Building Renewal project and plan to conduct an integrated cost-schedule risk and uncertainty analysis when the design is complete. You also noted that neither our policies and guidance required, nor our cost estimate reports for the Dome Restoration project contained the reasons for contingency amounts. We will revise our policies and guidance to require this information going forward. Although we have received contractor pricing for the Dome Restoration project's options one and two, and thereby face less cost risk, we are considering performing a risk and uncertainty analysis for one or both of these options.
- **Compare the point estimate to an independent cost estimate.** GAO's guide appears to contemplate one estimate being performed by the organization benefiting from the project, and a second estimate being done by a separate, independent organization. In our process, the benefiting organization does not perform the primary cost estimate. It is performed by a contractor being overseen by the AOC's Project Management Division. The Project Management Division is part of AOC's Planning and Project Management (PPM) organization, which is separate and apart from the benefiting jurisdiction. Our Cost Estimating Group, which is in PPM's Technical Support Division, is responsible for reviewing cost estimates. Thus, while cost estimates are overseen and reviewed within PPM, these functions are carried out by staff who work under different supervisors. When we obtain a second estimate – performed by a different contractor and subcontractors – for specific projects, the organizational set up is the same. While we believe that this

See comment 1.

See comment 2.

arrangement provides reasonable separation, we will revise our policies and guidance to require second estimates for all high dollar value projects, and ensure that our Cost Estimating Group has sufficient capacity to review the estimates.

Another issue discussed in the report is that our cost estimate reports do not include all costs. That is, our estimating contractor estimates construction contract costs, but not other costs, such as AOC management costs, life-cycle costs, or contingencies. Our policies and guidance did not require life-cycle costs, and we provide the estimating contractor percentage ranges for estimating the other costs. The December 2013 update to our Project Management Manual requires the use of life-cycle cost analysis. We will explore alternative approaches for estimating non-construction contractor costs.

- **Update estimates to reflect actual costs and changes.** We update our estimates to reflect changes in scope or design prior to construction contract award. We also perform independent estimates for changes to contracts. However, as a practice, we have not updated estimates with actual cost data once construction begins. This is for two reasons. First, we do not receive actual costs from our contractors because our contracts are firm fixed price. Recognized as most appropriate for construction because the price is not subject to any adjustment on the basis of the contractor's actual costs, a firm fixed price contract places the maximum risk and responsibility for all costs and resulting profit or loss on the contractor. The invoices we receive are based on price, not costs. During the course of your review, your staff indicated that this information may be obtainable if we were to pay contractors for it. Second, we do not believe having actual costs for projects underway or completed will usually be cost beneficial for future estimates because the prices we receive are market driven. However, there are certain instances in which having actual cost information may be cost beneficial. We will explore those types of situations for which having actual cost will be beneficial and various approaches for obtaining these data. In addition, we will revise our policies and guidance to require comparison of invoice data to our cost estimates for new, high dollar value projects at the aggregate cost element level, such as for construction cost, AOC management costs, and contingencies. Although we currently use earned value analysis and cash flow curves to track costs against contract prices for large projects based on contractor payments, we have not tracked such costs against our estimates.
- **Present estimates to management.** Our policies and guidance require a written report to management on cost estimates, but do not require a management briefing, which would be consistent with the leading practice in your guide. Your draft report also noted that management briefings on the Dome Restoration project's estimated costs were not well documented, despite our efforts to demonstrate that numerous briefings – to both internal AOC management and Congressional decision makers – were held about this very high-profile project. We will revise our policies and guidance to require management briefings as well as written reports on cost estimates for high dollar value projects. We will also specify the content of these briefings to be consistent with your guide, and will require the briefings to be documented along with management's decisions related to the estimates.

- **Identify ground rules and assumptions.** Although our policies and guidance require ground rules and assumptions to be listed in estimate reports, they do not require that the risk impacts be identified if assumptions turn out to be incorrect, and the estimate reports for the Dome Restoration project did not list assumptions or their risk impacts. For the Dome Restoration project, the assumptions were converted to contract specifications when the construction contract was developed. The risk impacts were addressed, but this process was not documented. Our policies and guidance will be revised to emphasize the importance of listing the assumptions and require identifying the risk impacts in the cost estimate reports even if they are shown in the contract specifications.

Regarding your recommendation that we provide confidence levels derived from risk and uncertainty analyses we perform on projects for which appropriated funding is being requested, we will explore developing a framework of best practices for performing sensitivity, risk, and uncertainty analyses to serve as the basis for setting contingency amounts on high dollar value projects. We will continue to prepare our cost estimates with the appropriate contingency levels based on project risks and complexity, and will explore the most effective approach for communicating this information to Congressional decision makers.

Cannon Project Estimation Process

We appreciate the recognition of the thoroughness of our estimating process for the Cannon Building Renewal project. There are, however, four issues on which we would like to provide additional comments.

First, your draft report discusses three matters that are said to affect the quality of the risk and uncertainty analysis performed on the Cannon Building Renewal project's cost estimate. While the conditions your draft report discusses are correct, we believe they relate to the context of the conditions existing at the time of the analysis rather than its quality.

1. **The confidence level exceeded 90 percent, which may be unreasonably high.** Given the need to maintain a \$753 million budget, the project's early stage of design, and the significant risks associated with the project, we believe that the 90 percent confidence level is reasonable at this time. Risks include a significant amount of work scope that is still being defined, the known presence of hazardous materials, the 10-year construction duration period, having to perform the work in an occupied building, and the historic nature of the building. We will reconsider the desired confidence level after the design is complete.
2. **The distribution of estimated costs at various confidence levels was unusually narrow.** According to our construction management contractor, MBP-AECOM, this situation is not unusual for construction projects. In construction projects, cost components can be broken into labor, equipment and installed material. Due to the competitive market, the cost variation between the optimistic and pessimistic values (uncertainty modelling) can be narrow, whether it is related to the labor, equipment, or material. For the Cannon Building Renewal project, at this stage of design development, one of the key variables is confidence in the "quantity take off," which is a function of the level of design development, which in turn is a

See comment 3.

See comment 4.

See comment 4.

function of scope definition. These uncertainties in the estimate were factored in the cost risk analysis, including external risks as identified in the project risk register.

3. **Risk impacts were not analyzed individually, thereby preventing a determination as to which risks have the greatest impact and limiting AOC's ability to manage risks.** Because of the project's early design stage and the associated uncertainties, our contractor, MBP-AECOM, did not believe that it would be meaningful or cost beneficial to apply the risks individually at this time. However, it does plan to do this when it performs the next risk and uncertainty analysis when the design is complete. With regard to AOC's ability to manage risks on the project, we have a structured, systematic risk-management program in place for the Cannon Building Renewal project. We maintain a project risk register that prioritizes risks based on the probability of occurrence and the severity of impacts on cost and schedule. These risk items are updated monthly as to how the mitigation strategies are progressing. Additionally, the entire project team meets on a quarterly basis to review the existing risks and identify additional risks. Therefore, we do not believe that the way information from the risk register was used or quantified in performing the cost risk analysis has impaired the project team's effectiveness in managing risks. In fact, the project team has been proactively identifying and managing risk from the onset of this project.

See comment 5.

Second, your draft report notes that you could not determine if the cost estimate was adjusted properly for inflation because all the information necessary to do this was not located in our files. Although this is correct, our contractors that performed the escalation analyses were willing to make this information available to GAO at the AOC's offices, and we did make this offer to your staff. To address the issue you raised, we will reassess our policies and guidance in this area to determine whether it is practical and cost beneficial to maintain this information at the AOC.

See comment 6.

Third, your draft report notes that the estimate did not include full life-cycle costs. We presume this meant life-cycle costs for all elements of the scope of work. Regarding the modernization of existing historic buildings, life-cycle cost analysis for major building elements, such as structure and façade cladding is not applicable. As GAO noted, our design contractor performed important life-cycle cost analysis regarding the selection of an appropriate mechanical system. During the Program of Requirements phase of the project, the contractor performed a comprehensive analysis of eight mechanical system options that included conceptual layouts and extensive energy modeling. The recommended mechanical system achieved the best balance of fixed costs, ongoing maintenance costs, and other important selection criteria. Also, it is important to note that the AOC and our design contractor, Construction Manager as Agent (CMa), and Construction Manager as Constructor (CMc) partners are performing ongoing value analysis of alternative strategies for materials and systems regarding each submission as the design documents are further developed.

Fourth, in Appendix III, your draft report notes that soft costs and contingencies, comprising a substantial portion of total program costs, were only superficially addressed. We provided GAO with a narrative description of our soft cost rationale and a project budget with tabs of detailed information regarding soft cost line items. Although soft costs were not addressed in a similar manner as construction costs (reconciliation of multiple estimates), the AOC and our CMa have spent considerable time reducing soft cost risk. Most importantly, we have firm fixed price contracts

from design development through project completion for a large portion of the soft costs including design costs, project management costs (CMa), and contractor preconstruction services (CMc). We have developed an AOC staffing plan through project completion as well as the related cost estimate. We have coordinated with the U.S. Capitol Police regarding estimates for construction security. We are working closely with the House Chief Administrative Officer in refining estimates for furniture, fixtures, and equipment. We have a dedicated team working on swing space that has developed cost estimates. Under our CMc contracting method, we will be awarding a Guaranteed Maximum Price contract and will be reviewing both our construction contractor's and subcontractors' pricing before contract award and when we receive monthly invoices. Finally, we have established contingencies based on industry best practices relative to the unique risks associated with the Cannon Building Renewal project.

Dome Project Estimation Process

Your draft report also contained a number of statements on the Capitol Dome Restoration project's cost estimating process that we believe warrant additional discussion.

- **Your draft report notes that we did not conduct quantitative sensitivity or risk and uncertainty analyses, use actual contractor cost data from previous projects, or document the reasons for the contingency amounts.** We did, however, perform these analyses qualitatively and considered costs we paid for the Dome Skirt Restoration project – completed in September 2012 – and used this information in developing our cost estimate and contingency. We also used this information to limit our risks in the contract documents. Consequently, the contract prices for the remaining Dome Restoration construction work are within 10 percent of our cost estimate. Without having a quantitative risk and uncertainty analysis, the draft report says that you could not see how the actions we took related to other risk mitigation efforts and why we chose the ones we did over others, and that we could not determine the appropriate contingency level. We addressed the risks we identified as having the greatest potential effect on cost based on the Dome Skirt Restoration work and our experience on other projects. We believe this gave us a reasonable basis for setting the contingency. We acknowledge that we did not always rigorously document this work and that a quantitative risk and uncertainty analysis may further strengthen our estimates. To address the issues you raised, we plan to revise our policies and guidance to emphasize the importance of adequately documenting our estimation steps, including setting contingencies and further documenting briefings to management.
- **We did not use actual costs from completed phases to update our estimate.** We used information from the Dome Skirt Restoration work in the estimation process. This enabled us to build on our experience from the most recent Dome Restoration work, specifically as it related to identifying cost drivers, market impacts, and risk management. We acknowledge that the use of these data was not well documented in our files.
- **We did not update our estimate with actual costs as the work progressed.** Doing this is not part of our estimation process. To address this issue, we will revise our policies and guidance to require comparison of our estimates to actual invoices we receive for high dollar

See comment 7.

See comment 8.

See comment 8.

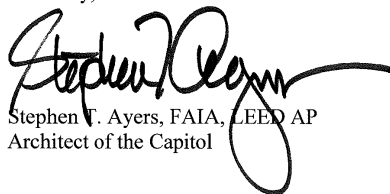
See comment 9.

value projects. We will also explore obtaining actual cost data for selected projects where we believe it will be cost beneficial. We believe it is necessary to exercise prudence on this issue because obtaining actual cost data on firm fixed price contracts will likely add cost to the project but may have limited value in determining the reasonableness of estimates because the market will likely drive the cost we eventually pay.

- **Indicies used for escalation appeared outdated.** As the draft report indicates, we estimate costs at various stages of the design process and the estimate reports from contractors are often revised after the AOC reviews them. In this case, we inadvertently did not initially provide the most recent version of the estimate report with the correct inflation data. However, we did provide it during the course of your field work.
- **The cost estimate report did not include a comprehensive list of assumptions.** This is because we converted the assumptions made during the design process into contract specifications, such as enumerating the allowable times construction work could be carried out. We will revise our policies and guidelines to emphasize the importance of including this list and the associated risk impacts in the estimate report even when assumptions are incorporated into contract documents.

Again, thank you for the opportunity to review and comment on this draft report. We believe that implementing the recommendations will further improve our cost estimating process. At the same time, although we have not always fully documented all the steps we take, we have a robust cost estimating process that embraces industry best practices and produces credible and reliable results. This is amply demonstrated by the recent on time and within budget completion of the Capitol Dome Skirt Restoration and the Inaugural Stand construction projects. Please don't hesitate to contact me should you have any questions on our comments.

Sincerely,



Stephen F. Ayers, FAIA, LEED AP
Architect of the Capitol

Doc. No. 140314-16-01

The following are GAO's comments on the Architect of the Capitol's letter dated March 14, 2014.

GAO Comments

1. We continue to believe that a quantitative risk and uncertainty analysis enables more effective oversight than can be obtained by taking a qualitative approach. A quantitative risk and uncertainty analysis conveys the confidence level in achieving the most likely cost and provides actionable information about cost, schedule, and technical risks that cannot be obtained qualitatively.
2. While AOC's contractors act independently, AOC's Project Management Division is responsible for the estimates prepared via contract, and AOC's Cost Estimating Group is responsible for reviewing them. Because AOC's Project Management Division and Cost Estimating Group staff are part of the same Planning and Project Management organization, the Cost Estimating Group staff could be biased because of organizational influences and unable to provide a fully objective review of costs to the Project Management Division.
3. While our leading practices do not specify target confidence levels, experts we consulted with in developing our leading practices agreed that program cost estimates should be budgeted to at least the 55 percent confidence level and potentially as high as 80 percent. While AOC has good reasons for its interest in maintaining the project's budget at a high confidence level, we believe that the confidence level for the project's budget—exceeding 90 percent—may be excessive.
4. AOC identified 60 risks to the project and modeled them in aggregate, as opposed to individually, in conducting its quantitative risk and uncertainty analysis. Modeling the aggregated risks precludes AOC from identifying relationships among risk elements and determining which risks have the greatest influence on project costs. We continue to believe that modeling the risks in aggregate likely contributes to the overly narrow range of estimated costs over the confidence levels, and can overstate the effect of the risks.
5. Our leading practices indicate that an estimate's documentation should be detailed enough so that the derivation of each cost element can be traced to all sources allowing the estimate to be easily replicated and updated. Because some information was not readily available in documents maintained by AOC, we were unable to determine if the estimate has been adjusted properly for inflation.
6. AOC has taken positive steps in conducting a life-cycle cost analysis that considered fixed costs and ongoing maintenance costs to inform

the AOC's selection of mechanical systems for heating and cooling the Cannon Building. However, AOC did not conduct life-cycle analyses for other components of the project, such as the building's roof and alarm system. This precludes AOC from capturing the total cost of the project and evaluating design alternatives on a total-cost basis.

7. AOC takes positive steps to *qualitatively* identify risks and uncertainty and assess sensitivity. While this analysis is useful in setting contingencies and managing risks during construction, a *quantitative* risk and uncertainty analysis enables more effective oversight because it conveys the confidence level in achieving the most likely cost and provides actionable information about cost, schedule, and technical risks that cannot be obtained qualitatively.
8. While AOC has used some information from completed phases of the Capitol Dome's restoration project to inform development of the estimate for later phases, not having information on actual costs makes it difficult for AOC to assess the difference between the price it paid and its contractors' costs to determine the estimate's reasonableness.
9. Our leading practices indicate that an estimate's documentation should be detailed enough so that the derivation of each cost element can be traced to all sources allowing the estimate to be easily replicated and updated. Because some information was out-of-date at the time of our review, we were unable to determine if the estimate had the proper escalation adjustments.

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

Lorelei St. James, (202) 512-2834 or stjamesl@gao.gov

Staff Acknowledgments

In addition to the contact named above Michael Armes, Assistant Director; Karen Richey, Assistant Director; George Depaoli, Analyst-in-Charge; Laura Erion; Emile Ettedgui; Colin Fallon; Geoffrey Hamilton; James Manzo; Faye Morrison; and Vanessa Welker made key contributions to this report.

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