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October 2015

AMPHIBIOUS COMBAT VEHICLE

Some Acquisition Activities Demonstrate Best Practices; Attainment of Amphibious Capability to be Determined

GAO-16-22

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GAO Highlights

Highlights of GAO-16-22, a report to congressional committees

Why GAO Did This Study

The Marine Corps' ACV is intended to transport Marines from ship to shore and provide armored protection on land. It is to potentially replace all or a portion of the decades old AAV fleet, and is expected to eventually offer increased amphibious capability and high water speed.

The National Defense Authorization Act for Fiscal Year 2014 included a provision that GAO annually review and report on the ACV program until 2018. This report provides an updated discussion of (1) how the ACV program's efforts compare to acquisition best practices and examines (2) how the increments of ACV will achieve amphibious capability.

To conduct this work, GAO reviewed program documentation and other materials for the ACV acquisition and Navy surface connector programs. GAO identified acquisition and analysis of alternatives best practices based on its prior body of work and DOD guidance. GAO also interviewed program and agency officials.

What GAO Recommends

GAO is not making recommendations in this report. In commenting on a draft of this report, DOD stated that it believes its efforts are aligned with best practices and that GAO's report appears to underestimate ACV 1.1's planned technical maturity. GAO found that some program plans do not align with best practices and that while some aspects of the acquisition do suggest lower levels of risk, these deviations could potentially increase program risk. GAO will continue to monitor these risks as the program moves forward.

View GAO-16-22. For more information, contact Marie A. Mak at (202) 512-4841 or makm@gao.gov.

What GAO Found

Most of the current activities of the U.S. Marine Corps' Amphibious Combat Vehicle (ACV) program have demonstrated the use of best practices, but plans for an accelerated acquisition schedule pose potential risks. As the program approaches the start of engineering and manufacturing development, it is seeking to rely on mature technologies that have been demonstrated to work in their intended environment as well as fostering competition—a critical tool for achieving the best return on the government's investment. Further, GAO analyzed the ACV analysis of alternatives that the Marine Corps produced for the initial portion of the ACV development, finding that overall it met best practices by, for example, ensuring that the analysis of alternatives process was impartial. However, the Marine Corps is pursuing an accelerated program schedule that presents some risks, including plans to hold the preliminary design review after the start of development—a deviation from best practices which could postpone the attainment of information about whether the design performs as expected. Moreover, GAO believes that the level of planned concurrency—conducting development testing and production at the same time—could leave the program at greater risk of discovering deficiencies after some systems have already been built, potentially requiring costly modifications. Agency officials stated that mature technologies reduce risk and that, while some concurrency is planned, all required testing will be completed prior to the production decision. While some aspects of this acquisition do suggest lower levels of risk, these deviations could potentially increase program risk. GAO will continue to monitor this risk as the program moves forward.

The ACV program relies heavily on future plans to increase ACV amphibious capability gradually, in three planned increments known as ACV 1.1, 1.2, and 2.0, but exactly how this capability will be attained has not yet been determined.

- ACV 1.1 – Although this increment is expected to have some amphibious capability, according to program documents, it is expected to rely on surface connector craft—vessels that enable the transportation of military assets from ship to shore. Marine Corps and U.S. Navy officials regularly coordinate ACV 1.1 plans to operate with the surface connector fleet through coordination mechanisms such as the Surface Connector Council.

- ACV 1.2 – This increment is expected to have greater amphibious capability, including the ability to self-deploy from ships. Based on demonstrations from related programs to date, program officials believe it will reach that capability, but indicated that plans for 1.2 are expected to depend on the success of ACV 1.1 development.

- ACV 2.0 – This increment represents a future decision point when the Marine Corps plans to determine how to replace the Assault Amphibious Vehicle (AAV) fleet. The Marine Corps is currently exploring technologies that may enable high water speed—a significant increase from the amphibious goals identified for ACV 1.1. Therefore, how it will achieve the amphibious capability envisioned for ACV 2.0 is undetermined.

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Abbreviations

AAV	Assault Amphibious Vehicle
ACV	Amphibious Combat Vehicle
AOA	analysis of alternatives
CDR	critical design review
DOD	Department of Defense
EFV	Expeditionary Fighting Vehicle
EPF	Expeditionary Fast Transport
ESD	Expeditionary Transfer Dock
JCIDS	Joint Capabilities Integration Development System
LCAC	Landing Craft Air Cushion
LCCE	life-cycle cost estimate
LCU	Landing Craft Utility
NPV	net present value
PDR	preliminary design review
SC(X)R	Surface Connector (X) Replacement
SME	subject matter expert
SS	sea state
SSC	Ship to Shore Connector
ST	short tons
SWH	significant wave height
TRA	technology readiness assessment
TRL	technology readiness level
USMC	United States Marine Corps
WBS	work breakdown structure

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Congressional Committees

Since 1972, the primary platform for transporting Marines from ship to shore under hostile and hazardous conditions has been the Assault Amphibious Vehicle (AAV). In 2011, acquisition of a proposed replacement vehicle—the United States Marine Corps' (USMC) Expeditionary Fighting Vehicle (EFV)—was canceled following the expenditure of $3.7 billion from fiscal year 1995 through 2011 due to concerns regarding the program's affordability. Also in 2011, USMC subsequently began the acquisition process for the Amphibious Combat Vehicle (ACV), a potential replacement vehicle for all or a portion of the AAV fleet. The ACV is intended to transport Marines from ship to shore and provide armored protection once on land. The ACV acquisition approach calls for ACV development in three increments with increasing amphibious capability, ACV 1.1, 1.2 and 2.0., with ACV 1.1 scheduled to start development in November 2015.

The National Defense Authorization Act for Fiscal Year 2014 included a provision for us to annually review and report to the congressional defense committees on the ACV program until 2018.[1] Previous reports in 2014 and 2015 described the efforts to initiate the ACV program and how its incremental acquisition approach compares to acquisition management best practices.[2] This report provides an updated discussion of (1) how the ACV program's efforts compare to acquisition best practices, and examines (2) how the increments of ACV are to achieve amphibious capability. This report also includes updates to the analysis of alternatives (AOA) best practices identified in prior GAO work.[3] These

[1]Pub. L. No. 113-66, § 251 (2013). The ACV program is relatively early in the acquisition process. As a result, we were unable to review all of the elements in the mandate since the ACV program has not yet progressed to those stages in the acquisition process.

[2]GAO, *Status of Efforts to Initiate an Amphibious Combat Vehicle Program*, GAO-14-359R, (Washington, D.C.: Apr. 10, 2014) and *Amphibious Combat Vehicle Acquisition: Marine Corps Adopts an Incremental Approach*, GAO-15-385, (Washington, D.C.: Apr. 15, 2015).

[3]GAO, *DOE and NNSA Project Management: Analysis of Alternatives Could Be Improved by Incorporating Best Practices*, GAO-15-37 (Washington, D.C.: Dec. 11, 2014).

updated best practices supersede those AOA best practices published in prior reports.

To conduct this work, we reviewed program documentation and other materials for the ACV 1.1 acquisition, including the acquisition strategy, technology readiness assessment and 2014 ACV AOA, as well as program documentation from Navy surface connector programs.[4] We identified acquisition best practices based on our extensive body of work in that area and Department of Defense (DOD) guidance, and used this information to analyze the proposed ACV acquisition approach and acquisition activities to date. We updated and refined the GAO-identified AOA best practices by soliciting comments on those best practices from a group of internal and external experts and vetting these comments with GAO experts. The resulting changes include the consolidation of some best practices, reducing the number from 24 to 22, and the establishment of four characteristics that identify a high-quality, reliable AOA process. Appendix I contains additional information on these best practices. We also reviewed our previous work on the ACV and EFV programs. In addition, we interviewed program and agency officials from the USMC's Advanced Amphibious Assault program office and Combat, Development, and Integration Division, the Office of the Secretary of Defense, Cost Assessment and Program Evaluation, the Naval Sea Systems Command, and the Office of the Assistant Secretary of the Navy for Research, Development, and Acquisition. Appendix II contains additional details about our scope and methodology.

We conducted this performance audit from May 2015 to October 2015 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

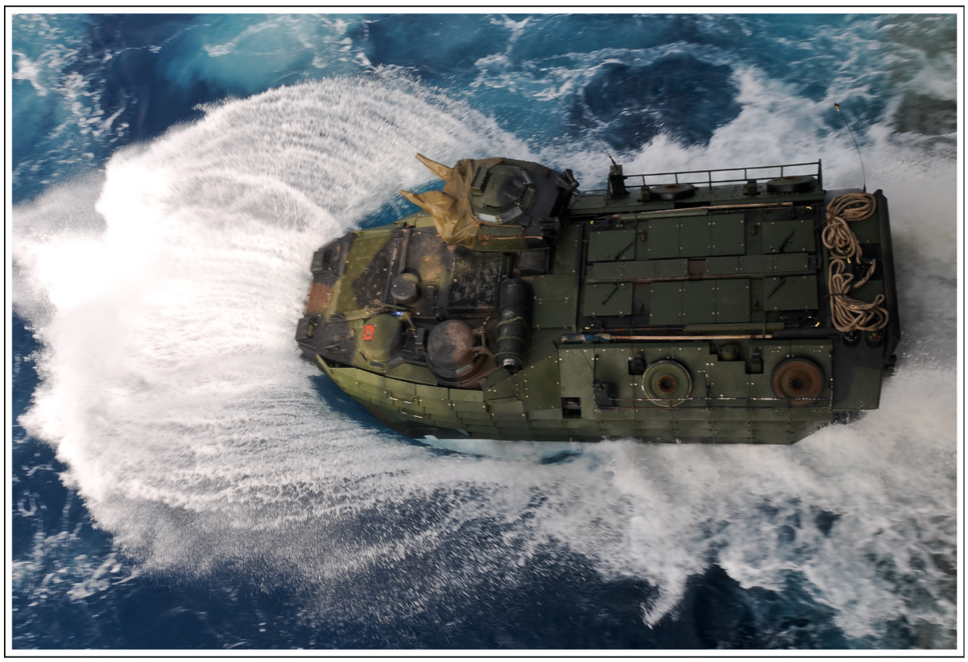
Background

The AAV is a tracked (non-wheeled) vehicle with the capability to self-deploy—or launch from ships (see figure 1). The AAV has a water speed

[4]Surface connector craft are vessels that enable the transportation of military assets from ship to shore. ACV 1.1 is expected to rely on surface connector craft for such transportation.

of approximately six knots, and is usually deployed from within sight of the shore, a factor that poses survivability risks in certain threat environments. According to USMC officials, the AAV has become increasingly difficult to maintain and sustain. As weapons technology and the nature of threats have evolved over the past four decades, the AAV is viewed as having limitations in water speed, land mobility, lethality, protection, and network capability. According to DOD, the need to modernize USMC's ability to move personnel and equipment from ship to shore is essential. In the last 15 years, USMC has undertaken a number of efforts to do this.

Figure 1: United States Marine Corps' Assault Amphibious Vehicle



Source: United States Marine Corps. | GAO-16-22

EFV: USMC began development of the EFV in 2000.[5] The EFV was to travel at higher water speeds—around 20 knots—which would have allowed transporting ships to launch the EFV further from shore than the

[5]The EFV entered the acquisition process in 1995 as the Advanced Amphibious Assault Vehicle.

AAVs it was to replace. However, following a 2007 breach of a statutory cost threshold, that program was restructured and subsequently, in 2011, canceled by DOD due to affordability concerns.[6]

ACV: In 2011, the USMC completed initial acquisition documentation providing the performance requirements for a new replacement amphibious vehicle called the ACV. The ACV was expected to be self-deploying with a water speed of 8 to 12 knots which would permit deployment beyond the visual range of the shore, but would not achieve high water speed.[7] It was also expected to provide for sustained operations on shore with improved troop protection. However, USMC leadership then requested an affordability analysis be completed that would explore the technical feasibility of integrating high water speed into ACV development. According to DOD officials, the analysis indicated that achieving high water speed was technically possible but required unacceptable tradeoffs as the program attempted to balance vehicle weight, capabilities, and cost. Meanwhile, the USMC retained a requirement to provide protected land mobility in response to the threat of improvised explosive devices—a requirement the AAV could not meet due to its underbody design. In 2014 we reported that, according to program officials, the program office was in the process of revising its ACV acquisition approach based on this affordability analysis.

ACV 1.1, 1.2 and 2.0: In 2014, the USMC revised its ACV acquisition approach, adopting a plan to develop the ACV in three increments:

- The first increment of ACV development—ACV 1.1—is planned to be a wheeled vehicle that would provide improved protected land mobility

[6]Section 2433 of title 10 of the United States Code, commonly referred to as Nunn-McCurdy, requires DOD to notify Congress whenever a major defense acquisition program's unit cost experiences cost growth that exceeds certain thresholds. This is commonly referred to as a Nunn-McCurdy breach. Significant breaches occur when the program acquisition unit cost or procurement unit cost increases by at least 15 percent over the current baseline estimate or at least 30 percent over the original estimate. For critical breaches, when these unit costs increase at least 25 percent over the current baseline estimate or at least 50 percent over the original, DOD is required to take additional steps, including conducting an in-depth review of the program. Programs with critical breaches must be terminated unless the Secretary of Defense certifies to certain facts related to the program and takes other actions, including restructuring the program. 10 U.S.C. § 2433a.

[7]The ACV program has evolved since this time. The current requirements for the ACV 1.1 include a water speed of 5 to 8 knots.

and limited amphibious capability. The ACV 1.1 is expected to be part of an amphibious assault through the use of surface connector craft to travel from ship to shore. Surface connectors are vessels that enable the transportation of military assets, including personnel, material, and equipment, from a sea base or ship to the shore.[8] ACV 1.1, a successor to the previously suspended Marine Personnel Carrier program, is using prototypes, demonstration testing, and other study results from that program.[9] DOD officials estimated that, in comparing the past Marine Personnel Carrier program and the ACV 1.1 as currently envisioned, the two are about 98 percent the same. Troop capacity—nine for the Marine Personnel Carrier and a threshold, or minimum, of 10 for the ACV 1.1—is the main difference between the two. Figure 2 provides a notional drawing of the ACV 1.1.

- The second increment—ACV 1.2—adds two variants of the vehicle for other uses and aims to improve amphibious capability. Program officials anticipate that it will demonstrate amphibious capability that matches the AAV, including the ability to self-deploy and swim to shore. According to DOD officials, ACV 1.2 will be based on the results of ACV 1.1 testing and it is anticipated that some 1.1s will be upgraded with ACV 1.2 modifications.

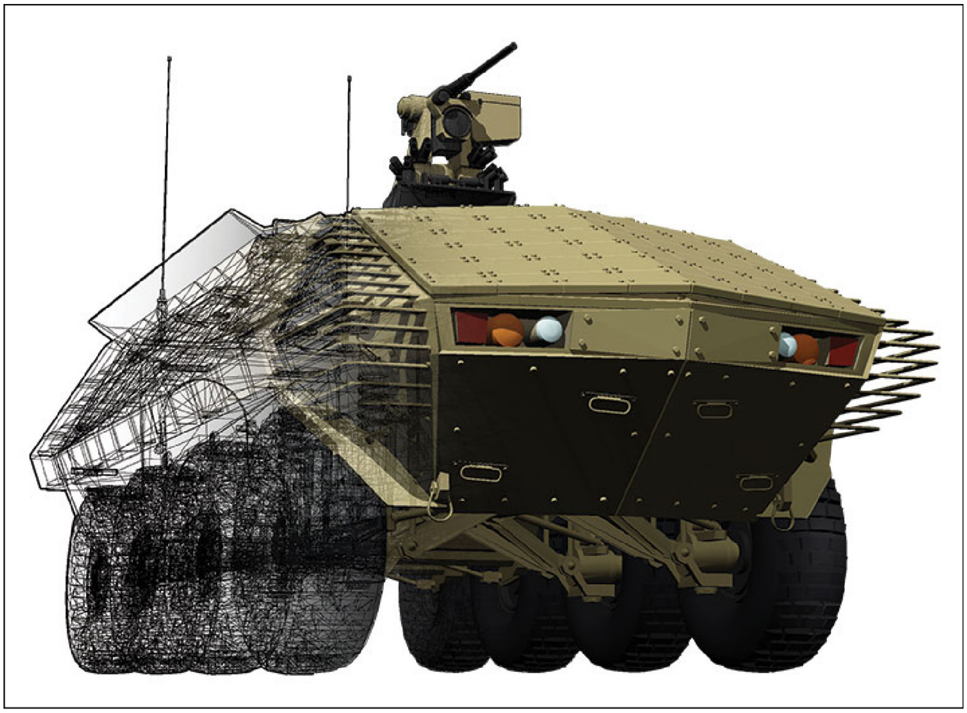
- The third effort, referred to as ACV 2.0, focuses on technology exploration to attain high water speed—a critical capability, according to DOD officials. These technology exploration efforts are seeking design options that may enable high water speed capability without accruing unacceptable trade-offs in other capabilities, cost or schedule. According to officials, ACV 2.0 is a conceptual placeholder for a future decision point when the Marine Corps plans to determine

[8]A sea base is an area that is intended to “provide a sovereign, maneuverable and secure area that can be used to assemble, project and sustain combat power relatively unconstrained by political and diplomatic restrictions.” United States Navy, Sea Base Branch, Expeditionary Warfare Directorate, *Sea Base Branch: Transforming Naval Expeditionary Warfare for a New Strategic Environment*, accessed on September 2, 2015, http://www.navy.mil/N85/SB.html.

[9]The Marine Personnel Carrier program, suspended in 2013, was intended to provide armor-protected transportation of Marines. According to USMC officials, budget uncertainty led the USMC to determine that it could not afford to have three simultaneous development and procurement programs for armored vehicles, specifically the ACV, the Marine Personnel Carrier, and the Joint Light Tactical Vehicle. After considering strategic priorities, the USMC decided to suspend the Marine Personnel Carrier program and continue with the ACV and Joint Light Tactical Vehicle.

how to replace the AAV fleet, which is expected to occur in the mid-2020s. High water speed capability may ultimately be achieved through an amphibious vehicle or a surface connector craft.

Figure 2: Notional Drawing of Amphibious Combat Vehicle 1.1



Source: United States Marine Corps. | GAO-16-22

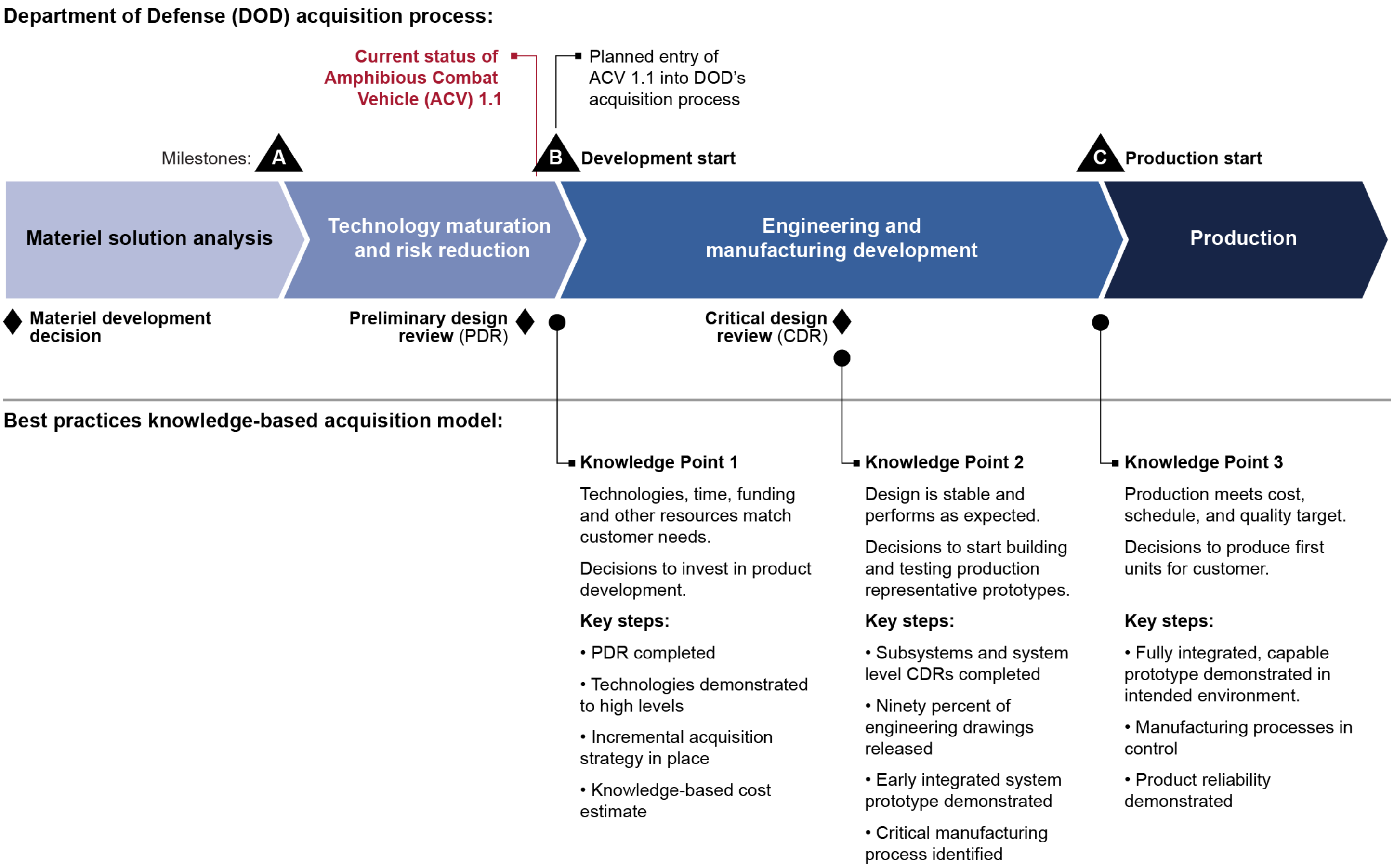
Knowledge-Based Acquisition Framework

Our prior work on best practices has found that successful programs take steps to gather knowledge that confirms that their technologies are mature, their designs are stable, and their production processes are in control.[10] The knowledge-based acquisition framework involves achieving the right knowledge at the right time, enabling leadership to make informed decisions about when and how best to move into various acquisition phases. Successful product developers ensure a high level of knowledge is achieved at key junctures in development, characterized as knowledge points. Knowledge Point 1 falls early in the acquisition process

[10]For example, see GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-15-342SP, (Washington, D.C.: Mar. 12, 2015 [Re-issued Apr. 9, 2015]).

and coincides with a program's acquisition's decision to begin development, referred to as Milestone B. At this knowledge point, best practices are to ensure a match between resources and requirements. Achieving a high level of technology maturity and preliminary system design backed by robust systems engineering is an important indicator of whether this match has been made. This means that the technologies needed to meet essential product requirements have been demonstrated to work in their intended environment. In addition, the developer has completed a preliminary design of the product that shows the design is feasible. Figure 3 identifies the ACV 1.1 acquisition's status within the DOD acquisition process.

Figure 3: Alignment of DOD's Acquisition Process and Best Practices



Source: GAO analysis of DOD-provided data, DOD Instruction 5000.02, "Operation of the Defense Acquisition System" (January 7, 2015) and GAO's best practices. | GAO-16-22

Early ACV Acquisition Activities Demonstrate Best Practices

Our review of the available documents that have been prepared to inform the November 2015 decision to begin system development of ACV 1.1—including the acquisition strategy and an updated 2014 AOA—found that most of the ACV program's acquisition activities to date reflect the use of best practices. The incremental approach to achieving full capability itself is consistent with best practices. The ACV 1.1 acquisition strategy minimizes program risk by using mature technology, competition, and fixed-price type-contracts when possible. In addition, our analysis of the 2014 AOA found that overall it met best practices. Going forward, however, some elements of the acquisition approach, for example, the program's plan to hold a preliminary design review (PDR)—a technical review assessing the system design—after beginning development, do not align with best practices and could increase program risk. While some aspects of this acquisition do suggest lower levels of risk, these deviations could potentially increase program risk. GAO will continue to monitor this risk as the program moves forward.

Aspects of the ACV 1.1 Acquisition Strategy Demonstrate Efforts to Minimize Risk

The ACV 1.1 acquisition strategy prepared to inform the upcoming start of engineering and manufacturing development minimizes program risk by following best practices, such as using mature technology, competition, and fixed-price-type contracts when possible.

Technology maturity. The ACV program plans to utilize mature technology in ACV 1.1 development. According to acquisition best practices, demonstrating a high level of maturity before allowing new technologies into product development programs puts programs in a better position to succeed.[11] To support a decision to begin development, a technology readiness assessment (TRA) was performed to assess the maturity of critical technologies to be integrated into the program. DOD defines critical technology elements as new or novel technology that a platform or system depends on to achieve successful development or production or to successfully meet a system operational threshold requirement. In a TRA, identified critical technologies are assessed against a technological readiness level (TRL) scale of 1 to 9. Specifically, a rating of TRL 1 demonstrates "basic principles observed and reported," and TRL 9 demonstrates "actual system proven through successful

[11]GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

mission operations."[12] Overall, the completed ACV 1.1 TRA assessed the program at TRL 7, indicating demonstration in an operational environment. This assessment was based on the non-developmental nature of the vehicles,[13] the use of mature technology for modifications, and tests and demonstrations of prototype vehicles done under the Marine Personnel Carrier program.

The TRA identified two critical technology elements. One version of a critical technology—the Drivers Vision Enhancement—had not been proven in the marine environment. Subsequent to the TRA report, the version selected was replaced by a system that has been used on the AAV for 10 years and is proven in a marine environment. As a result, it is assessed at a TRL 8. The second critical technology, the Remote Weapon Station, was assessed at TRL 7. However, the operational environment in which this technology has been demonstrated is not the same environment it will face as part of the ACV 1.1. Specifically, the ACV 1.1 is expected to operate in a marine environment and, therefore, the weapon system must be prepared to function and be maintained in the same environment. According to agency officials, some of the mitigation steps that have been identified to help prepare the system for the marine environment, specifically, incorporating techniques used on another version of the system that is fielded on a Navy patrol boat, have not yet been applied. These factors add an element of risk to the use of the technology and suggest a lower assessed level of technology maturity that is in line with DOD policy and statute,[14] which generally require a TRL 6 prior to starting development, but is not in line with best practices, which call for a TRL 7.[15] In the acquisition strategy, the program has

[12]Department of Defense, *Technology Readiness Assessment (TRA) Deskbook* (July 2009).

[13]A non-developmental item is a previously developed item of supply used exclusively for governmental purposes by a Federal agency, a State or local government, or a foreign government with which the U.S. has a mutual defense cooperation agreement; or such an item that only requires minor modifications or modifications of a type customarily available in the commercial marketplace in order to meet the requirements of the procuring agency; or any item of supply being produced that doesn't meet this definition solely because the item is not yet in use. Federal Acquisition Regulation (FAR) § 2.101.

[14]A major defense acquisition program generally may not receive approval for system development start until the milestone decision authority certifies that the technology in the program has been demonstrated in a relevant environment. 10 U.S.C. § 2366b(a)(3)(D).

[15]Demonstration in a relevant environment is TRL 6. Demonstration in an operational environment is TRL 7.

identified adapting the Remote Weapon Station to the marine environment as a principal program risk because using the system under different operational conditions may have a significant impact on system reliability. While the program has identified additional risk mitigation strategies—including planned component testing during development and development of preventative maintenance procedures—this technology could entail a somewhat higher level of risk than the TRL level suggests and may require additional attention as development begins.

Competition. According to our prior work, competition is a critical tool for achieving the best return on the government's investment.[16] The ACV acquisition approach has fostered competition in the acquisition process, both through competitive prototyping that took place prior to the start of development and with competition that continues through development until production. Specifically, before the Marine Personnel Carrier program was suspended, the government awarded a contract to test critical sub-systems including the engine, transmission, suspension and hydraulic hardware systems. The government also awarded four contracts for system-level prototypes demonstrating the swim capability, personnel carry capability, and survivability of each company's vehicle. The Under Secretary of Defense for Acquisition, Technology, and Logistics—the ACV Milestone Decision Authority—has certified to the congressional defense committees that the ACV program had met the competitive prototyping requirement based on the work done under the Marine Personnel Carrier program. In addition, after development begins, the program plans to award ACV 1.1 development contracts to two vendors, maintaining competition until they select one vendor at the start of production.

Contract strategy. When development begins, the ACV program plans to award hybrid contracts to each of the to-be-selected developers. According to program plans, each contract is to utilize three different pricing structures for different activities: fixed-price-incentive for ACV 1.1

[16]GAO-15-342SP.

vehicle development,[17] firm-fixed-price for the delivery incentive to deliver test vehicles early,[18] and cost-plus-fixed-fee[19] for test support and advanced capability improvements and studies. According to the Federal Acquisition Regulation, it is usually to the Government's advantage for the contractor to assume substantial cost responsibility and an appropriate share of the cost risk; therefore, fixed-price incentive contracts are preferred when contract costs and performance requirements are reasonably certain.[20] Manufacturing the development vehicles is the largest anticipated portion of ACV development contract costs. According to the ACV 1.1 acquisition strategy, a fixed-price-incentive contract is considered the most appropriate contract type to utilize for the vehicle's development because the vehicles themselves are non-developmental in nature but there is some risk related to the integration of selected systems, such as the Remote Weapon Station, and other modifications required to meet USMC requirements. Meanwhile, the strategy states that the delivery incentive is to be a firm-fixed-price, as the fee is a set dollar amount based on how early the vehicles are delivered and is not subject to adjustment based on the vendor's costs.

Under cost-reimbursement contract types, such as a cost-plus-fixed-fee contract, the government bears the risk of increases in the cost of performance. Cost-reimbursement contract types are suitable when

[17]DOD plans for contractors to be incentivized to control vehicle development costs through the use of the fixed-price incentive pricing structure. A fixed-price incentive contract is a fixed-price contract that provides for adjusting profit and establishing the final contract price by application of a formula based on the relationship of total final negotiated cost to total target cost. The final price is subject to a price ceiling, negotiated at the outset. The ACV development contract is expected to share cost savings and cost overruns with the contractor using a 50/50 split and provide a cost ceiling of 120 percent of the target cost. FAR § 16.403.

[18]A firm-fixed price delivery incentive fee is also to be offered. The firm-fixed-price is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. The firm-fixed price delivery incentive fee is a set dollar amount that is to be determined based on how early the contractors deliver the prototype vehicles to the testing location. FAR § 16.202-1.

[19]For the cost-plus-fixed-fee activities, the government pays for allowable incurred costs to the extent prescribed in the contract, as well as a negotiated fee that is fixed at the outset. The contract establishes an estimate of total cost for the purpose of obligating funds and establishing a ceiling that the contractor may not exceed without the approval of the contracting officer. FAR § 16.301-1, 16.306(a).

[20]FAR § 16.401(c).

uncertainties in requirements or contract performance do not permit the use of fixed-price contract types. A cost-plus-fixed-fee structure is planned for test support before and after the start of production, vehicle transportation and other test-related activities. According to program officials, the scope and nature of these activities are difficult to predict, making the cost-plus-fixed-fee structure appropriate. Officials also stated that the cost-plus-fixed-fee activities are expected to comprise about 11 percent of the total contract value.

Requirements and cost estimates. Additional key documents have been prepared, or are underway, in accordance with DOD policy. The ACV 1.1 Capabilities Development Document, providing the set of requirements for development, is tailored specifically for ACV 1.1. In accordance with DOD policy, the ACV 1.1 Capabilities Development Document was validated prior to the release of the ACV 1.1 request for proposal in March 2015. In addition, best practices and DOD policy also call for the development of an independent cost estimate prior to the start of development. According to agency officials, the independent cost estimate is underway and will be prepared for the Milestone B decision. The acquisition strategy identifies no funding shortfalls for the program as of the fiscal year 2016 President's budget submission.

2014 ACV Analysis of Alternatives Met Best Practices

Our assessment of the 2014 AOA found that overall it met best practices for AOAs and is, therefore, considered reliable. An AOA is a key first step in the acquisition process intended to assess alternative solutions for addressing a validated need. AOAs are done or updated to support key acquisition decision points. The USMC completed an AOA update for ACV 1.1 in late 2014 to support the release of the ACV 1.1 request for proposal. Over the years, other AOAs have been completed for related acquisitions, including the EFV, the Marine Personnel Carrier and the previous version of the ACV considered in 2012. These previous AOAs and other supporting studies comprise a body of work that has informed the most recent ACV AOA update as well as the ACV 1.1 acquisition as a whole.

AOAs can vary in quality, which can affect how they help position a program for success. We have previously identified best practices for the development of AOAs.[21] Considered in the context of the related AOA body of work, the ACV AOA met 15 of the 22 AOA best practices, including ensuring that the AOA process was impartial and developing an AOA process plan, among others. Further, four of the remaining best practices were substantially met, two were partially met, and one was minimally met.[22] For example, best practices call for the documentation of all assumptions and constraints used in the analysis. We found that the 2014 AOA does not include a full list of assumptions and constraints and any assumptions or constraints from previous analysis, if relevant, were not updated or referenced in the new analysis. As a result, it could be difficult for decision makers to make comparisons and trade-offs between alternatives. Appendices I and II provide more information on the methodology used in this analysis and appendix III provides the results of our AOA analysis in greater detail. DOD's Cost Assessment and Program Evaluation staff also reviewed the 2014 AOA and found that it was sufficient. However, they identified a few areas of caution, including recommending additional testing of land mobility to further verify USMC assertions that the wheeled ACV 1.1 would have the same mobility in soft soil as tracked vehicles.

Accelerated Schedule Presents Program Risks

According to USMC officials, the ACV program is pursuing an aggressive schedule in order to obtain ACV 1.1 initial operational capability in fiscal year 2020. The program is scheduled to hold its PDR after development starts, a deviation from best practices. In addition, according to program officials, as a result of the aggressive acquisition schedule, the program plans on a higher level of concurrency between development testing and production than would take place under a more typical acquisition schedule.[23] This aggressive schedule may likely have congressional decision makers approve funds to begin production based on little to no evidence from the testing of delivered ACV 1.1 prototypes. Some factors may mitigate the risk posed by this acceleration, for example, program officials have stated that all required testing will take place prior to the

[21]GAO-15-37. This report provides an update to the best practices identified in GAO-15-37. See appendix I.

[22]See appendix II for assessment level definitions.

[23]Concurrency is broadly defined as the overlap between technology development and product development or between product development and production.

start of production. However, further attention may be warranted in our future reviews of the program's schedule.

The ACV 1.1 program is planning to hold its PDR about 90 days after development begins and to combine its PDR and the critical design review (CDR) into one event. Best practices recommend that the PDR is held before development begins in order to increase the knowledge available to the agency when development starts, for example, increasing confidence that the design will meet the requirements established in the Capabilities Development Document. The absence of a PDR introduces some risk by postponing the attainment of knowledge until after development begins and reducing scheduled time to address any design issues that may arise. In addition, it is a best practice to demonstrate design stability at the system-level CDR, completing at least 90 percent of engineering drawings at that time. Combining the PDR and CDR may limit the time available to the program to address any issues identified and ensure that sufficient knowledge is attained prior to the program moving forward. For example, in a 2006 report, we found that the EFV program's CDR was held almost immediately after the start of development—similar to the approach for ACV 1.1—and before the system integration work had been completed.[24] Testing of the early prototypes continued for three years into system development, well after the tests could inform the CDR decision. Best practices call for system integration work to be conducted before the CDR is held. According to DOD officials, the ACV 1.1 PDR will be held after Milestone B because contracts are not planned to be awarded prior to that time. In addition, DOD officials stated that the technological maturity of ACV 1.1 reduces risk and permits both the waiver of the PDR requirement and the consolidation of the reviews. While the use of mature technology could suggest a reduced risk from this deferral, we believe that contracts could have been awarded earlier in the acquisition process in order to facilitate a PDR prior to development start.

The current ACV 1.1 program schedule demonstrates concurrency between testing and production that could represent increased program risk. According to agency officials, approximately one year of development testing will take place prior to the program's production

[24]GAO, *Defense Acquisitions: The Expeditionary Fighting Vehicle Encountered Difficulties in Design Demonstration and Faces Future Risks*, GAO-06-349 (Washington, D.C.: May 1, 2006).

decision in order to assess production readiness. Another ten months of testing will continue after the start of production. The intent of developmental testing is to demonstrate the maturity of a design and to discover and fix design and performance problems before a system enters production. According to agency officials, the adoption of an accelerated fielding schedule is behind the level of overlap between developmental testing and production. They stated that they plan to have completed all development testing and operational assessment required to support the production decision by the time that decision is made. DOD policy allows some degree of concurrency between initial production and developmental testing and, according to our prior work, some concurrency may be necessary when rapidly fielding urgently needed warfighter capabilities. However, our past work has also shown that beginning production before demonstrating that a design is mature and that a system will work as intended increases the risk of discovering deficiencies during production that could require substantial design changes and costly modifications to systems already built. A detailed test plan will not become available until Milestone B as is expected for acquisition programs. When such a plan is available, we will further assess the risk presented by this approach.

Moreover, under the current ACV 1.1 program schedule, Congress may likely be called upon to provide production funding for ACV 1.1 production based on little to no evidence from the testing of delivered ACV 1.1 prototypes. The program is scheduled to make a production decision, and select one vendor, in fiscal year 2018. Under the normal budget process, Congress would be provided the request for funding that production with the President's budget in February 2017, around the same time that the prototype ACV 1.1 vehicles are scheduled to be delivered. In the event that the development testing schedule experiences delays and key tests are postponed until after the planned production decision, the program may face increased risk.

Incremental Development of Future Amphibious Capability Is Key to Current ACV Strategy

The success of the ACV acquisition strategy depends upon the attainment of improved amphibious capabilities over time. The first increment, ACV 1.1, is not expected to have ship to shore amphibious capability and thus is planned to use Navy surface connectors to travel from ship to shore. The USMC and the Navy have coordinated the planned operation of ACV 1.1 with surface connectors to ensure compatibility and availability. The ACV acquisition intends to rely heavily upon realizing a fully amphibious ACV 1.2, providing AAV-equivalent water mobility and the ability to self-deploy. However, the exact nature of

ACV 1.2 and 2.0 is unknown at this time. Achieving the planned capabilities of future ACV increments is highly dependent upon ACV 1.1 attaining its planned amphibious capability.

ACV 1.1 Expects to Rely on Surface Connector Craft for All Ship to Shore Transportation

While ACV 1.1 is expected to have shore to shore amphibious capability, which would enable the vehicle to cross rivers and inland waterways, the vehicle is also expected to rely on Navy surface connector craft for ship to shore transportation. Connectors have become increasingly important as USMC vehicles have grown in weight. According to USMC analysis, about 86 percent of USMC expeditionary force assets are too heavy or over-sized for air transport, and need to be transported by surface connectors.

The ACV 1.1 requirements include transportability by currently available and planned Navy surface connectors. Because several surface connectors can transport the ACV 1.1, the selection of specific surface connectors is planned to be based on an evaluation of mission needs and connector capabilities. Some current and planned Navy surface connectors that could transport ACV 1.1 are described below. Appendix IV provides additional information on the key capabilities of these connectors.

Landing Craft Air Cushion (LCAC). The LCAC is a high speed hovercraft that supports rapid movement from ship to shore, such as during an amphibious assault. The LCAC is one of the primary connectors that provide ship to shore transportation of equipment, personnel, and vehicles. The LCAC, which can access about 70 percent of the world's beaches, is optimized towards major combat operations and forcible entry. The Navy currently has a fleet of 72 LCACs which have received upgrades as a result of a service life extension program effort. The Navy also plans to provide additional LCAC maintenance until replacement craft are acquired.

Ship to Shore Connector (SSC). The Navy plans to replace each LCAC with an SSC. The SSC, similar in design to the LCAC, is planned to maintain or improve upon LCAC capabilities with an increased payload capacity, a longer service life, and the ability to operate in more harsh marine environments. SSC is planned to reach initial operational capability of 6 craft in 2020 and full operational capability in 2027.

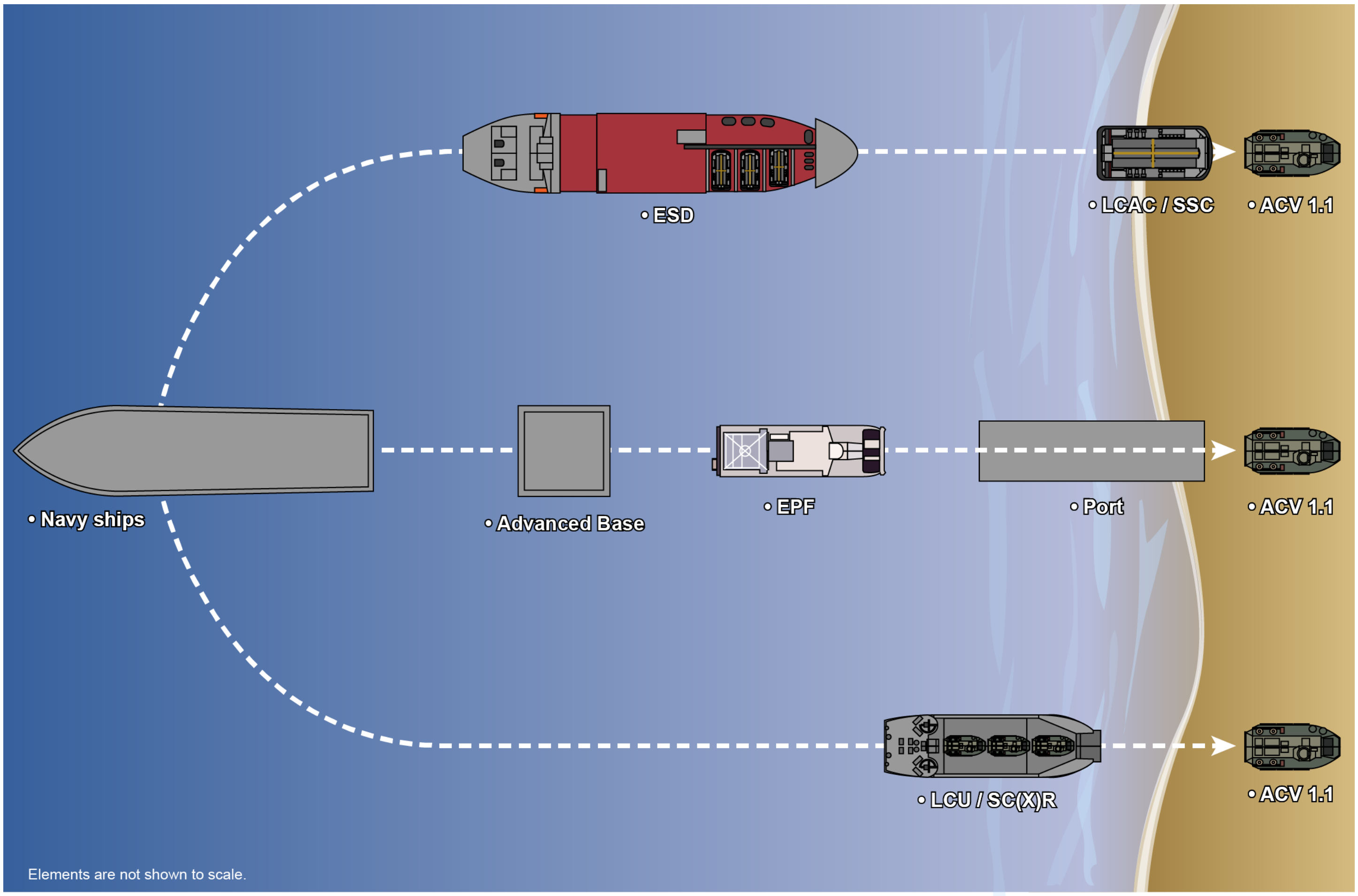
Landing Craft Utility (LCU). The LCU is a utility connector that supports ship to shore movement in amphibious assaults and also participates in a variety of other missions. The LCU has a large range and payload capacity, but operates at a slower speed compared to the LCAC. According to Navy officials, the LCU can access about 17 percent of the world's beaches, and stops at the waters' edge in order to unload its cargo.

Surface Connector (X) Replacement (SC(X)R). According to Navy officials, the aging LCU craft are planned to be replaced by SC(X)R craft in order to maintain a total of 32 LCUs and SC(X)Rs. According to the Surface Connector Council, the SC(X)R is likely to be larger and show improvements in materials, propulsion, maintainability, and habitability. Production for the SC(X)R is planned to begin in 2018.

Expeditionary Fast Transport (EPF). The EPF, formerly known as the Joint High Speed Vessel, is a commercial-based catamaran that provides heavy-lift, high-speed sealift mobility. The EPF uses a ramp system to allow vehicles to off-load at shipping ports or where developed infrastructure is unavailable (referred to as austere ports). The EPF is planned to reach full operational capability in the year 2019.

Figure 4 illustrates three examples of how various surface connectors could be used to transport ACV 1.1 from ship to shore. For example, ACVs could be loaded onto an Expeditionary Transfer Dock (ESD) and then on to LCACs or SSCs while the ESD maneuvers towards the shore. The LCACs or SSCs would then launch from the ESD and transport the ACVs to shore. The ACV could also be off-loaded at an advanced base —such as an island located within the operational area—and then loaded onto a EPF for transport to a developed or austere port. Finally, the ACVs could be directly loaded from ships on to a LCU or SC(X)R and taken to shore. This graphic includes selected examples only, and does not represent all possible transportation options.

Figure 4: Examples of ACV 1.1 Ship to Shore Transportation



ACV	Amphibious Combat Vehicle	**LCU**	Landing Craft Utility
EPF	Expeditionary Fast Transport	**SC(X)R**	Surface Connector X Replacement
ESD	Expeditionary Transfer Dock	**SSC**	Ship to Shore Connector
LCAC	Landing Craft Air Cushion		

Source: GAO presentation of U.S. Marine Corps and U.S. Navy information. | GAO-16-22

Navy Officials Have Taken Actions to Mitigate Potential SSC Risks

SSC acquisition risks may have consequences for employment of ACV 1.1. The Navy has identified that it requires a combined fleet of at least 72 operational LCACs and SSCs to support ship to shore transportation demands. However, the Navy previously anticipated a lack of available connectors from the year 2015 through 2024, with a maximum ‘gap,’ or shortage, of 15 craft in 2019. Navy officials said that this ‘connector gap’ has been mitigated with the extension of the LCAC service life extension program[25] and acceleration of the SSC acquisition.

In a previous assessment of the SSC program,[26] we found that the Navy recognizes three SSC technologies as potential risk areas, for which the Navy recommended further testing. According to officials, since that report, the Navy has completed additional testing for software, drivetrain components, and engine endurance to further develop and reduce the risk of these technologies. Navy officials said the SSC program plans to continue testing these technologies and remains on-schedule. However, the SSC program entered production in 2015, more than 2 years before the estimated delivery of the test vehicle. This concurrency of development and production creates a potential risk of schedule overruns if deficiencies in the design are not discovered until late in testing and retrofits are required for previously produced craft. Navy officials said that the LCAC service life could be further extended with additional sustainment funding in the event of SSC acquisition delays.

USMC and Navy Coordinated ACV and Surface Connector Plans with Various Mechanisms

The USMC and Navy regularly coordinate on the ACV 1.1 to facilitate the future use of the surface connector fleet through the Joint Capabilities Integration Development System (JCIDS), the Surface Connector Council, and other communication.

JCIDS. The JCIDS process is a DOD-wide process to identify and assess capability needs and their associated performance criteria. The Capabilities Development Document for the ACV 1.1 was developed as part of the JCIDS process. The document, among other things, identified key systems attributes, key performance parameters, and design requirements for the ACV 1.1 with input from the USMC, the Navy, and others. For example, it included design requirements that allow the SSC to transport two ACVs, and ensure that ACVs can be transported by other connector craft as well.

[25]The LCAC service life extension program began in 2005, and included a number of craft improvements that were expected to add about 10 years of service life to the fleet. The post-service life extension program will extend the use of 19 LCAC an additional 5 to 7 years. The post-service life extension program began in fiscal year 2015 and is planned to run through fiscal year 2020.

[26]GAO-15-342SP.

Surface Connector Council and working group. The Surface Connector Council serves as a mechanism through which the USMC and Navy coordinate activities related to surface connectors that are used for amphibious shipping. The council has two co-chairs: the Director of the Navy's Expeditionary Warfare Division and the Director of the USMC Capabilities Development Directorate who is also the Deputy Commandant for Combat Development and Integration. The council membership is drawn from several offices from both the Navy and the USMC. The Council is required to meet at least biannually but, according to Navy officials, in practice the Council generally meets quarterly. At these meetings, the Council has previously discussed ACV program risks, such as connector availability and the scarcity of space on connectors, and associated risk mitigation strategies, according to Navy officials. The Surface Connector Council also has a working level forum, known as the Surface Connector Roundtable, which meets on a monthly basis according to Navy officials.

Informal discussions. In addition to coordination through JCIDS and the Surface Connector Council, officials said that informal discussions between USMC and Navy officials occur frequently to coordinate the ACV and connector programs.

Future Amphibious Capability to be Determined

The exact nature of the ACV's future amphibious capability is not yet known. USMC officials are confident that the ACV 1.1 would not only meet its minimum requirements for shore to shore swim capability, but may exceed those requirements and be able to swim from ship to shore. Based on tests and demonstrations to date, program officials also expressed confidence that ACV 1.2 will build on the ACV 1.1 capabilities and have the ability to self-deploy from ships. However, according to DOD officials, the capabilities of the ACV 1.2 are dependent upon the success of ACV 1.1 development. If the ACV 1.1 does not demonstrate the expected amphibious capabilities, then more development than currently anticipated may be required for ACV 1.2 to achieve ship to shore amphibious capability and greater effort may be needed to retro-fit ACV 1.1 vehicles to achieve the same capabilities. However, if ACV 1.1 demonstrates greater than expected amphibious capability, then the progression towards achieving the plans for the ACV 1.2 may be easier. Program documentation and analysis to date have been done to develop the ACV 1.1 strategy and plans and to support ACV 1.1 decisions. According to DOD officials, the USMC has not yet determined whether the development of ACV 1.2 will be done through improvements within the same program or as a separate program from ACV 1.1. DOD officials stated that the development of ACV 1.1 and 1.2 amphibious capabilities is also expected to impact the nature of ACV 2.0. According to DOD officials, with the ACV 2.0 decision, the ACV program expects to achieve high water speed, a long-standing goal and a significant increase from the current amphibious goals identified for ACV 1.1.

The current USMC amphibious strategy plans for an evolving mix of ACVs and upgraded and legacy AAVs that are to maintain the needed combination of capabilities at any one time. According to USMC officials, over time, the ACV program plans to replace portions of the AAV fleet with ACV increments as they become available. This USMC strategy, and the analysis that supports it, is based on the assumption that ACV 1.2 will reach a desired level of amphibious capability and that ACV 1.1 vehicles can be upgraded to that level. If, however, those or other key capabilities cannot be achieved, revisiting the USMC's strategy prior to making production decisions for ACV 1.1, particularly addressing changes to its overall amphibious strategy and potentially updating its analysis of alternatives, will be important. In addition, when and how the USMC will achieve the amphibious capability envisioned for ACV 2.0 remains to be determined, according to DOD officials. We will continue to monitor these issues along with the program's performance against best practices as it progresses toward the Milestone C production decision currently planned for the second quarter of fiscal year 2018.

Agency Comments and Our Evaluation

We are not making any recommendations in this report. DOD provided written comments on a draft of this report. The comments are reprinted in appendix V.

In commenting on a draft of this report, DOD stated that it believes its efforts on this program are aligned with our best practices and that our report appears to underestimate ACV 1.1's planned technical maturity and associated risks. DOD stated that the vehicle is beyond the traditional PDR and CDR level of maturity and conducting a combined PDR and CDR is appropriate for the level of risk identified by the Program Manager. As we stated in this report, the program's plan to hold a PDR after beginning development does not align with best practices and combining the PDR and CDR may limit the time available to the program to address any issues identified and ensure that sufficient knowledge is attained prior to the program moving forward. Further, as we stated earlier, while some aspects of this acquisition do suggest lower levels of risk, these deviations could potentially increase program risk—risks that we will continue to monitor as the program moves forward.

DOD also provided technical comments that were incorporated, where appropriate.

We are sending copies of this report to interested congressional committees; the Secretary of Defense; the Under Secretary of Defense for Acquisition, Technology, and Logistics; the Secretary of the Navy; and the Commandant of the Marine Corps. This report also is available at no charge on GAO's website at http://www.gao.gov.

Should you or your staff have any questions on the matters covered in this report, please contact me at (202) 512-4841 or makm@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix VI.

Marie A. Mak
Director, Acquisition and Sourcing Management

List of Committees

The Honorable John McCain
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Committee on Appropriations
House of Representatives

Appendix I: Best Practices for the Analysis of Alternatives Process

Background and Introduction

Many guides have described an approach to analyses of alternatives (AOAs); however, there is no single set of practices for the AOA process that has been broadly recognized by both the government and private-sector entities. GAO has identified 22 best practices for an AOA process by (1) compiling and reviewing commonly mentioned AOA policies and guidance used by different government and private-sector entities and (2) incorporating experts' comments on a draft set of practices to develop a final set of practices.[1]

These practices can be applied to a wide range of activities in which an alternative must be selected from a set of possible options, as well as to a broad range of capability areas, projects, and programs. These practices can provide a framework to help ensure that entities consistently and reliably select the project alternative that best meets mission needs. The guidance below is meant as an overview of the key principles that lead to a successful AOA process and not as a "how to" guide with detailed instructions for each best practice identified.

The 22 best practices that GAO identified are grouped into the following five phases:

1. **Initialize the AOA process:** includes best practices that are applied before starting the process of identifying, analyzing, and selecting alternatives. This includes determining the mission need and functional requirements, developing the study time frame, creating a study plan, and determining who conducts the analysis.
2. **Identify alternatives**: includes best practices that help ensure the alternatives to be analyzed are sufficient, diverse, and viable.
3. **Analyze alternatives**: includes best practices that compare the alternatives to be analyzed. The best practices in this category help ensure that the team conducting the analysis uses a standard, quantitative process to assess the alternatives.
4. **Document and review the AOA process**: includes best practices that would be applied throughout the AOA process, such as documenting all steps taken to initialize, identify, and analyze alternatives and to select a preferred alternative in a single document.

[1]The best practices listed in this appendix are an update of and supersede the initial set of 24 best practices listed in GAO-15-37.

5. **Select a preferred alternative**: includes a best practice that is applied by the decision maker to compare alternatives and to select a preferred alternative.

The five phases address different themes of analysis necessary to complete the AOA process and comprise the beginning of the AOA process (defining the mission needs and functional requirements) through the final step of the AOA process (select a preferred alternative).

There are three key entities that are involved in the AOA process: the customer, the decision maker, and the AOA team. The customer refers to the program office, service, or agency that identifies a mission need (e.g. a credible gap between current capabilities and those required to meet the goals articulated in the strategic plan). The decision maker is the person or entity that signs off on the final decision and analysis documented by the AOA report. The decision maker refers to the program manager (or alternate authority figure identified early in the AOA process) who will select the preferred alternative based on the established selection criteria. The AOA team is the group of subject matter experts who are involved in the day-to-day work of the AOA process and work to develop the analysis that is the foundation of the AOA process.

Conforming to the 22 best practices helps ensure that the preferred alternative selected is the one that best meets the agency's mission needs. Not conforming to the best practices may lead to an unreliable AOA, and the customer will not have assurance that the preferred alternative best meets the mission needs. Table 1 shows the 22 best practices and the five phases.

Table 1: Best Practices for the Analysis of Alternatives (AOA) Process

Phase I. Initialize the AOA process

1. Define mission need

Definition: The customer defines the mission needs (i.e., a credible gap between current capabilities and those required to meet the goals articulated in the strategic plan) without a predetermined solution. To ensure that the AOA process does not favor one solution over another, the AOA is conducted before design and development of the required capabilities. The customer decides at which level of design completion an AOA should be performed, with the understanding that the more complete the design, the more information is available to support a robust analysis and to select a preferred alternative that best meets the mission need.

Effect: Allowing mission needs to be defined in solution-specific terms creates a potential bias and could invalidate the analysis.

2. Define functional requirements

Definition: The customer defines functional requirements (i.e. the general parameters that the selected alternative must have to address the mission need) based on the mission need without a predetermined solution. The customer defines the capabilities that the AOA process seeks to refine through characterized gaps between capabilities in the current environment and the capabilities required to meet the stated objectives for the future environment. These functional requirements are realistic, organized, clear, prioritized, and traceable. It is advisable that functional requirements be set early in the AOA process and agreed upon by all stakeholders.

Effect: The AOA process is tied to the identified mission needs. Setting functional requirements to a standard other than mission needs allows bias to enter the study because the requirements might then reflect arbitrary measures. Additionally, requirements not tied to mission needs make it difficult to quantify the benefits of each alternative relative to what is required and make it challenging for decision makers to assess which capability gaps will be met for each alternative.

3. Develop AOA time frame

Definition: The customer provides the team conducting the analysis enough time to complete the AOA in order to ensure a robust and complete analysis. Since an AOA process requires a large team with many diverse resources and expertise, the process requires sufficient time to be accomplished thoroughly. A detailed schedule is developed prior to starting the AOA process. The duration of the AOA process depends on the number of viable alternatives and availability of the team members. The time frame is tailored for the type of system to be analyzed and ensures that there is adequate time to accomplish all of the AOA process steps robustly.

Effect: The AOA process identifies and thoroughly analyzes a comprehensive range of alternatives. Recommending an alternative without adequate time to perform the analysis is a contributing factor to high dollar acquisitions that have significantly overrun both cost and schedule while falling short of expected performance.

4. Establish AOA team

Definition: After the customer establishes the need for the AOA in steps 1 through 3, a diverse AOA team is established to develop the AOA. This team consists of members with a variety of necessary skill sets, specific knowledge, and abilities to successfully execute the study. For example, the AOA team includes individuals with skills and experience in the following areas: program management, federal contracting, cost estimating, risk management, sustainability, scheduling, operations, technology, earned value management, budget analysis, and any other necessary areas of expertise.

Effect: An AOA process includes a diverse group of subject matter experts (SMEs) to perform the analysis. Since each SME brings their knowledge to the team, without the appropriate expertise on the team, errors in the results could occur and gaps in the analysis could be created, causing the AOA's completion to be delayed as more SMEs are identified and tasked to work as part of the AOA process.

5. Define selection criteria

Definition: The AOA team or the decision maker defines selection criteria based on the mission need. The defined criteria are based on mission needs and are independent of a particular capital asset or technological solution. The selection criteria are defined based on the mission need prior to starting the analysis.

Effect: It is essential that the selection criteria be based on the mission needs. If there are no preset criteria based on documented requirements, bias can enter the AOA process and prevent the decision maker from forming an impartial and unbiased decision.

6. Weight selection criteria

Definition: The AOA team or the decision maker weights the selection criteria to reflect the relative importance of each criterion. While the selection criteria are ranked in importance, the alternatives are based on trade-offs between costs, operational effectiveness, risks, schedules, flexibility, and other factors identified by the team or the decision maker.

Effect: An unjustified weighting method can oversimplify the results and potentially mask important information leading to an uninformed decision.

7. Develop AOA process plan

Definition: The AOA team creates a plan to include proposed methodologies for identifying, analyzing, and selecting alternatives prior to beginning the AOA process. This plan establishes the critical questions to be explored, the selection criteria, the basis of estimates, and measures that are used to rate, rank, and decide among the alternatives. Additionally, the plan includes the criteria used to determine each alternative's viability. A road map and standard work breakdown structure (WBS) are used to compare the alternatives with the baseline and with each other.

Effect: The functional requirements and selection criteria are identified prior to the beginning of the analysis. If criteria to select the preferred alternative are established after the analysis has begun bias may influence the study's results. Furthermore, if planned methodologies for the remaining phases of the AOA study are not established, the risk of applying poor methodologies as part of the AOA analysis increases.

Phase II. Identify alternatives

8. Develop list of alternatives

Definition: The AOA team identifies and considers a diverse range of alternatives to meet the mission need. To fully address the capability gaps between the current environment and the stated objectives for the future environment, market surveillance and market research is performed to develop as many alternative solutions as possible for examination. Alternatives are mutually exclusive, that is, the success of one alternative does not rely upon the success of another.

Effect: An AOA process encompasses numerous alternatives in order to ensure that the study provides a broad view of the issue. If the AOA team does not perform thorough research to capture diverse alternatives, the optimal alternative could be overlooked and invalidate the AOA's results and bias the process.

9. Describe alternatives

Definition: The AOA team describes alternatives in sufficient detail to allow for robust analysis. All alternatives' scope is described in terms of functional requirements. This description is detailed enough to support the viability, cost, and benefit/effectiveness analyses.

Effect: Documentation is essential for validating the AOA process and defending its conclusions. Unless the AOA team adequately describes and documents the alternatives, the analysis will not provide sufficient detail to allow for valid cost-benefit estimates and will not be credible.

10. Include baseline alternative

Definition: The AOA team includes one alternative to represent the status quo to provide a basis of comparison among alternatives. It is critical for the AOA team to first understand the status quo, which represents the existing capability's baseline where no action is taken, before comparing alternatives. The baseline is well documented as an alternative in the study and is used to represent the current capabilities and also for explicit comparison later in the study.

Effect: It is essential that the AOA process compare the current environment with the possible future environment. If no status quo is examined, then there is no benchmark for comparison, allowing arbitrary comparisons between alternatives and hindering the credibility of the study.

11. Assess alternatives' viability

Definition: The AOA team screens the list of alternatives to eliminate those alternatives that are not viable, and it documents the reasons for eliminating any alternatives. All alternatives are examined using predetermined qualitative technical and operational factors to determine their viability. Only those alternatives found viable are examined fully in the AOA process. However, all assumptions regarding the alternatives' viable and nonviable status are fully documented, including reasons that an alternative is not viable, in order to justify the recommendation. Additionally, viable alternatives that are not affordable within the projected available budget are dropped from final consideration.

Effect: Not eliminating alternatives based on viability could needlessly extend the study's duration and burden the AOA team or lead to the selection of a technically nonviable alternative. Furthermore, unless the AOA team considers affordability as part of the final recommendation, an alternative that is not feasible based on the current fiscal environment could be selected. Documenting the alternatives that are deemed nonviable is important so that decision makers can clearly see why those alternatives are not considered for further analysis.

Phase III. Analyze alternatives

12. Identify significant risks and mitigation strategies

Definition: The AOA team identifies and documents the significant risks and mitigation strategies for each alternative. Risks are ranked in terms of significance to mission needs and functional requirements. All risks are documented for each alternative along with any overarching or alternative specific mitigation strategies. Schedule risk, cost risk, technical feasibility, risk of technical obsolescence, dependencies between a new project and other projects or systems, procurement and contract risk, and resources risks are examined.

Effect: Since AOA processes typically occur early in the acquisition process, risk is inherently a part of every alternative. Not documenting the risks and related mitigation strategies for each alternative prevents decision makers from performing a meaningful trade-off analysis necessary to choose a recommended alternative.

13. Determine and quantify benefits/effectiveness

Definition: The AOA team uses a standard process to document the benefits and effectiveness of each alternative. The AOA team drafts a metric framework that details the methods used to evaluate and quantify the measures of effectiveness and measures of performance for all mission needs. The AOA team quantifies the benefits and effectiveness of each alternative over the alternative's full life-cycle, if possible. Just as costs cover the entire life-cycle for each alternative, the benefits and effectiveness measures cover each alternative's life-cycle, if possible, in order to determine each alternative's net present value (NPV)—the discounted value of expected benefits minus the discounted value of expected costs. In cases where the means to monetize a benefit are too vague (for example, intangibles like scientific knowledge), the AOA team treats those benefits as strategic technical benefits and uses scalability assessments to quantify those benefits so that they are compared across all viable alternatives. In situation where benefits cannot be quantified, the AOA team explains why this is the case as part of their analysis.

Effect: Determining a standard process to quantify benefits is an essential part of the AOA process. If the AOA team does not clearly establish criteria against which to measure all alternatives, bias is introduced to the study. Additionally, if the AOA team does not examine effectiveness over the entire life-cycle, decision makers cannot see the complete picture and are prevented from making an informed decision.

14. Tie benefits/effectiveness to mission need

Definition: The AOA team explains how each measure of effectiveness supports the mission need. The AOA team shows how the measures of effectiveness describe the way the current environment is expected to evolve to meet the desired environment; the team also shows how the measures are tied to specific mission needs and functional requirements. This is the hierarchy that connects the overarching requirements to the data that are needed.

Effect: Unless the AOA team thoroughly documents how the measures of effectiveness relate to specific mission needs and functional requirements, decision makers will not have proper insight into the impact of each alternative.

15. Develop life-cycle cost estimates (LCCEs)

Definition: The AOA team develops a LCCE for each alternative, including all costs from inception of the project through design, development, deployment, operation, maintenance, and disposal. The AOA team includes a cost expert who is responsible for development of a comprehensive, well-documented, accurate, and credible cost estimate for each viable alternative in the study. The LCCE for each alternative follows the GAO 12-step guide and uses a common cost element structure for all alternatives and includes all costs for each alternative.[a] Costs that are the same across the alternatives (for example, training costs) are included so that decision makers can compare the total cost rather than just the portion of costs that varies across all viable alternatives. The AOA team expresses the LCCE in present value terms and explains why it chose the specific discount rate used. The AOA team ensures that economic changes, such as inflation and the discount rate are properly applied, realistically reflected, and documented in the LCCE for all alternatives. Furthermore, the present value of the estimate reflects the time value of money—the concept that a dollar today can be invested and earn interest.

Effect: An LCCE that is incomplete (i.e. does not include all phases of an alternative's life-cycle) does not provide an accurate and complete view of the alternatives' costs. Without a full accounting of life-cycle costs, decision makers will not have a complete picture of the costs for each alternative and will have difficulty comparing the alternatives because comparisons may not be based on accurate information. Additionally, applying a discount rate is an important step in cost estimating because all cost data must be expressed in like terms for comparison. Unless the AOA team properly normalizes costs to a common standard, any comparison would not be accurate, and any recommendations resulting from the flawed analysis would be negated. Properly normalizing costs is particularly important if various alternatives have different life-cycles.

16. Include a confidence interval or range for LCCEs

Definition: The AOA team presents the LCCE for each alternative with a confidence interval or range, and not solely as a point estimate. To document the level of risk associated with the point estimate for each viable alternative, the confidence interval is included as part of the LCCE for each viable alternative (in accordance with GAO Cost Estimating Best Practice #9, risk and uncertainty analysis).[b] Decision makers must have access to the confidence interval associated with the point estimates for all viable alternatives in order to make informed decisions. Additionally, the AOA team uses a consistent method of comparing alternatives in order to present a comparable view of the risk associated with each alternative. For example, the comparison can be based on an established dollar value across alternatives (in order to observe the confidence level for each alternative at that dollar value). Alternatively, the comparison can be based on a predetermined confidence level across alternatives (in order to observe the dollar value associated with that confidence level for each alternative).

Effect: For decision makers to make an informed decision, the alternatives' LCCEs must reflect the degree of uncertainty. Having a range of costs around a point estimate is useful because it conveys a level of confidence for each alternative to achieve a most likely cost. Without cost risk and uncertainty analysis the LCCEs for the viable alternatives are not credible.

17. Perform sensitivity analysis

Definition: The AOA team tests and documents the sensitivity of the cost and benefit and effectiveness estimates for each alternative to risks and changes in key assumptions. Major outcomes and assumptions are varied in order to determine each alternative's sensitivity to changes in key assumptions. This analysis is performed in order to rank the key drivers that could influence the cost and benefit estimates based on how they affect the final results for each alternative. Each alternative includes both a sensitivity and risk and uncertainty analysis that identifies a range of possible costs based on varying key assumptions, parameters, and data inputs. As explained in best practice #16, life-cycle cost estimates are adjusted to account for risk and sensitivity analyses.

Effect: Failing to conduct a sensitivity analysis to identify the uncertainties associated with different assumptions increases the chance the AOA team will recommend an alternative without an understanding of the full impacts on life-cycle costs, which could lead to cost and schedule overruns.

Phase IV. Document and review the AOA process
18. Document AOA process in a single document *Definition*: The AOA team documents all steps taken to identify, analyze, and select alternatives in a single document. This document clearly states the preferred alternative and provides the detailed rationale for the recommendation based on analytic results. The report includes sections detailing the steps taken to initialize the AOA process, and to identify, analyze, and select alternatives. For example, one section lists the overall selection criteria and rationale for nonviable or viable ratings for alternatives, assumptions for each alternative, risk drivers and mitigation techniques, analysis of the costs and benefits associated with each alternative, and the trade-offs between costs, benefits, and risks. *Effect*: Documentation is essential for validating and defending the AOA process. Without clear reports that compile all information, including standards used to rate and perform the analysis, the study's credibility could suffer because the documentation does not explain the rationale for methodology or the calculations underlying the analysis. Having all the information related to all best practices of the AOA process in one single document also makes it easier for an independent reviewer to assess the AOA process.
19. Document assumptions and constraints *Definition*: The AOA team documents and justifies all assumptions and constraints used in the AOA process. Assumptions and constraints help to scope the AOA. Assumptions are explicit statements used to specify precisely the environment to which the analysis applies, while constraints are requirements or other factors that cannot be changed to achieve a more beneficial approach. Both assumptions and constraints are detailed and justified for each alternative in the AOA plan. *Effect*: Without documented and justified assumptions and constraints it will be difficult for decision makers to evaluate between the alternatives.
20. Ensure AOA process is impartial *Definition*: The AOA team conducts the analysis without a predetermined solution. The AOA process informs the decision-making process rather than reflecting the validation of a predetermined solution. The AOA process is an unbiased inquiry into the costs, benefits, and capabilities of all alternatives. *Effect*: An AOA process is not considered valid if it is biased. Performing a study with a predetermined solution distorts the results. The validity of the analysis is affected if bias is introduced to the inputs.
21. Perform independent review *Definition*: An entity independent of the AOA process reviews the extent to which all best practices are followed. The AOA process is completed with enough thoroughness to ensure that an independent organization outside of the project's chain of command can review the AOA documentation and clearly understand the process and rationale that led to the selection of the recommended alternative. Part of the documentation includes approval and review from an office outside of the one that asked for or performed the AOA process. For certain projects, in addition to an independent review at the end of the AOA process, additional independent reviews are necessary at earlier stages of the process, such as reviews of the AOA process plan of the identification of viable alternatives. While early reviews are not a substitute for the independent review conducted at the end of the AOA process, they help ensure that bias is not added throughout the course of the AOA process. *Effect*: An independent review is one of the most reliable means to validate an AOA process. Without an independent review, the results are more likely to include organizational bias or lack the thoroughness needed to ensure that a preferred solution is chosen and not a favored solution.
Phase V. Select a preferred alternative
22. Compare alternatives *Definition*: The AOA team or the decision maker compares the alternatives using NPV, if possible, to select a preferred alternative. NPV can be negative if discounted costs are greater than discounted benefits. NPV is the standard criteria used when deciding whether an alternative can be justified based on economic principles. In some cases, NPV cannot be used, such as when quantifying benefits is not possible. In these cases, the AOA team documents why NPV cannot be used. Furthermore, if NPV is not used to differentiate among alternatives, the AOA team should document why NPV is not used, and describe the other method that is used to differentiate, and explain why that method has been applied. *Effect*: Comparing items that have not been discounted (or normalized) does not allow for time series comparisons since alternatives may have different life cycles or different costs and benefits.

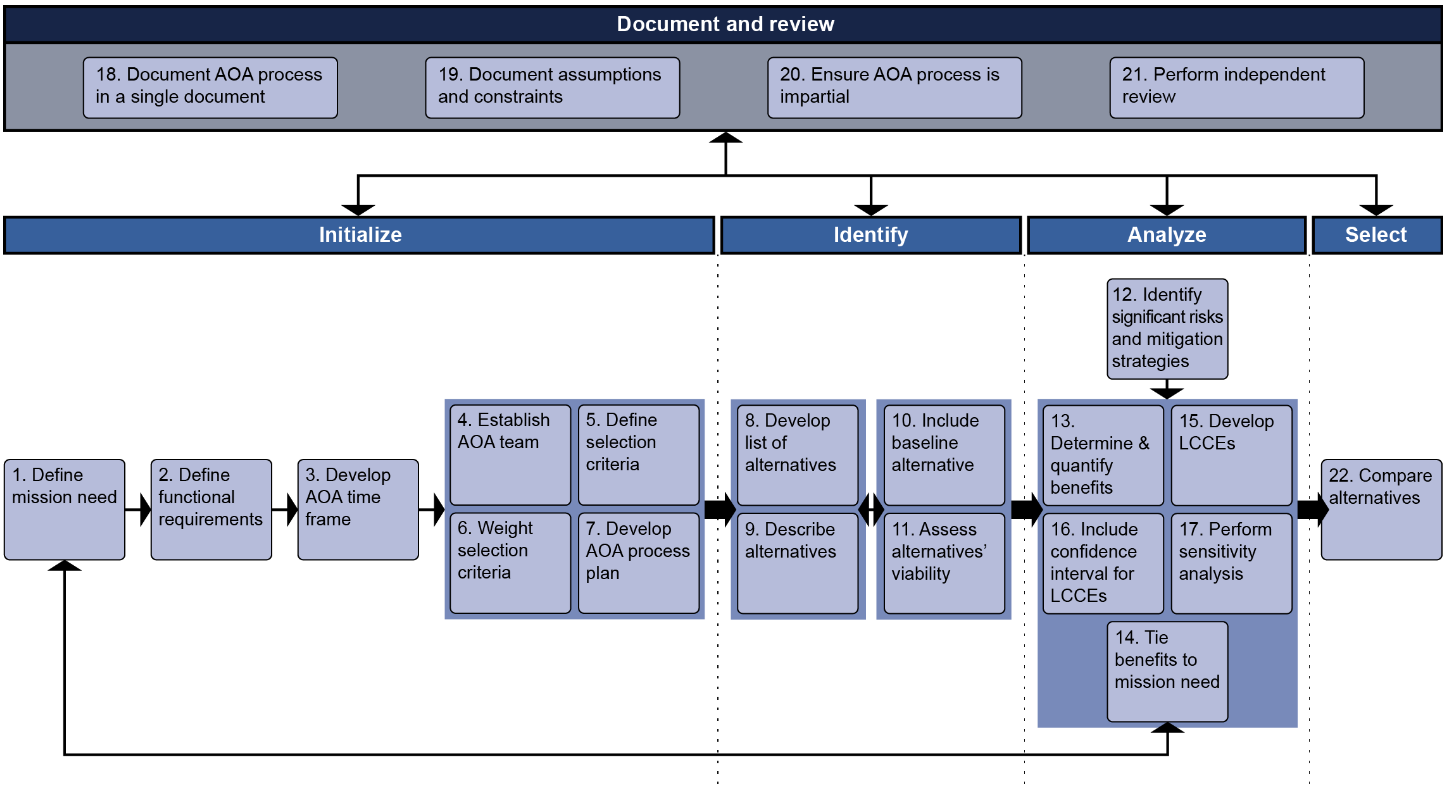
Source: GAO. | GAO-16-22

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

[b]GAO-09-3SP.

Some best practices included in a phase can take place concurrently and do not have to follow the order presented in table 1. The phases should occur in sequence to prevent bias from entering the analysis and adding risk that the AOA team will analyze alternatives that have not been defined. However, the document and review phase can be done at any stage throughout the AOA process. For example, best practice 5 (define selection criteria) can be done at the same time as best practice 6 (weight selection criteria). On the other hand, best practice 20 (ensure AOA process is impartial) can be done at the end of every step or every phase to ensure the impartiality of the AOA as it progresses. The best practices represent an overall process that results in a reliable AOA that can be easily and clearly traced, replicated, and updated. Figure 5 shows the AOA process and how the steps in each phase are interrelated.

Figure 5: AOA Process Chart



AOA Analysis of alternatives
LCCE Life-cycle cost estimate

Source: GAO. | GAO-16-22

Note: The figure displays the AOA process by phase and step. The "Initialize, Identify, Analyze, and Select" phases should be done in order, but the "Document and review" phase can be done throughout the AOA process. The arrows indicate that the "Document and review" phase is related to the other four phases. Within each phase, there are steps that can be done concurrently rather than consecutively. The concurrent steps are grouped together in dark blue boxes. Furthermore, there are steps in later phases that are related to steps in earlier phases; these are connected with a two way arrow

Review the AOA Process

An important best practice is an independent review of the AOA process. It is important that the AOA process and its results be validated by an organization independent of the program office and the project's chain of command, to ensure that a high-quality AOA is developed, presented, and defended to management. This process verifies that the AOA adequately reflects the program's mission needs and provides a reasonable assessment of the cost and benefits associated with the alternatives.

One reason to independently validate the AOA process is that independent reviewers typically rely less on assumptions alone and, therefore, tend to provide more realistic analyses. Moreover, independent reviewers are less likely to automatically accept unproven assumptions associated with anticipated savings. That is, they bring more objectivity to their analyses, resulting in a reality check of the AOA process that reduces the odds that management will invest in an unreasonable alternative.

To that end, we established four characteristics that identify a high-quality, reliable AOA process. These characteristics would evaluate if the AOA process is well-documented, comprehensive, unbiased, and credible.

- “Well-documented” means that the AOA process is thoroughly described in a single document, including all source data, clearly detailed methodologies, calculations and results, and that selection criteria are explained.
- “Comprehensive” means that the AOA process ensures that the mission need is defined in a way to allow for a robust set of alternatives, that no alternatives are omitted and that each alternative is examined thoroughly for the project’s entire life-cycle.
- “Unbiased” means that the AOA process does not have a predisposition toward one alternative over another; it is based on traceable and verifiable information.
- “Credible” means that the AOA process thoroughly discusses the limitations of the analyses resulting from the uncertainty that surrounds both the data and the assumptions for each alternative.

Table 2 shows the four characteristics and their relevant AOA best practices.

Table 2: Criteria and Characteristics

Characteristics	AOA process best practice
Well documented: The analysis of alternatives (AOA) process is thoroughly described, including all source data, clearly detailed methodologies, calculations and results, and selection criteria are explained. • Includes a detailed list of ground rules, assumptions, risks, and mitigation strategies needed to provide a robust analysis for all alternatives. • Explains how each alternative's identified measures of benefits/effectiveness support the mission needs. • Details in a single document all processes, criteria, and data used to support the AOA process's final decision. • Describes the estimating methodology and rationale used to build costs and benefits for all alternatives.	12. Identify significant risks and mitigation strategies 14. Tie benefits/effectiveness to mission need 18. Document AOA process in a single document 19. Document assumptions and constraints
Comprehensive: The level of detail for the AOA process ensures no alternatives are omitted and that each alternative is examined thoroughly for the project's entire life-cycle. • Identifies and screens a diverse range of alternatives. • Compares alternatives across their entire life-cycle rather than focusing on one phase of the acquisition process.	1. Define mission need 3. Develop AOA timeframe 8. Develop list of alternatives 11. Assess alternatives' viability 15. Develop life-cycle cost estimates (LCCEs)
Unbiased: The AOA process does not have a predisposition towards one alternative over another but is based on traceable and verified information • Defines the mission needs and functional requirements independently of an operational solution. • Ensures that the appropriate personnel are assigned to the task and there is enough time to complete a thorough study. • Documents a standard process that defines selection criteria based on mission need and quantifies the benefit/effectiveness measures to ensure the AOA process is conducted without a pre-determined solution in mind. • Compares solutions based on pre-established weighted selection criteria and net present value techniques.	2. Define functional requirements 4. Establish AOA team 6. Weight selection criteria 7. Develop AOA process plan 13. Determine and quantify benefits and effectiveness 20. Ensure AOA process is impartial 22. Compare alternatives
Credible: The AOA process discusses any limitations of the analysis resulting from the uncertainty surrounding the data to assumptions made for each alternative. • Includes a baseline scenario as the benchmark to enable comparison between alternatives. • Life-cycle cost estimates developed for each alternative include a confidence interval or range developed based on risk/uncertainty analysis. • Details the sensitivity of both costs and benefits to changes in key assumptions for all alternatives. • Independent review of the AOA process is performed to ensure that the study's results are logical and based on the documented data, assumptions, and analyses.	5. Define selection criteria 9. Describe alternatives 10. Include baseline alternative 16. Include a confidence interval or range for LCCEs 17. Perform sensitivity analysis 21. Perform independent review

Source: GAO. | GAO-16-22

Appendix II: Scope and Methodology

To determine how the ACV program's efforts compare with best practices, we reviewed program documentation and other materials for the ACV acquisition, including the acquisition strategy, technology readiness assessment, and the Capabilities Development Document. We identified acquisition best practices based on our extensive body of work in that area and Department of Defense (DOD) guidance, and used this information to analyze the proposed ACV acquisition approach and acquisition activities to date. We also reviewed our previous work on the ACV and EFV programs. In addition, we interviewed program and agency officials from the USMC's Advanced Amphibious Assault program office and Combat Development and Integration, Analysis Directorate, the Office of the Assistant Secretary of the Navy for Research, Development, and Acquisition, and the Office of the Secretary of Defense, Cost Assessment and Program Evaluation.

To determine the extent to which the 2014 ACV Analysis of Alternatives (AOA) demonstrated the use of best practices, we worked with USMC officials to identify the body of analyses that informed the 2014 AOA. Different pieces of each report or analysis in the full body of work were relevant to different best practices. Because the 2014 ACV AOA is part of a larger body of related work that informs this analysis, we then worked with GAO specialists to discuss the 22 AOA best practices and categorize each as either "individual" or "combined." Best practices labeled "individual" have been assessed based on only the 2014 ACV Analysis of Alternatives final report. Best practices noted as "combined" were assessed referring to the full body of work that, according to USMC officials, has informed the analysis of alternatives process. We then compared the 22 best practices to the 2014 AOA or the full body of AOA analysis, as determined above. We used a five-point scoring system to determine the extent to which the AOA conforms to best practices. To score each AOA process, (1) two GAO analysts separately examined the AOA documentation received from the agency and then agreed on a score for each of the 22 best practices, then (2) a GAO AOA specialist independent of the engagement team reviewed the AOA documentation and the scores assigned by the analysts for accuracy and cross-checked the scores in all the analyses for consistency. We first used this scoring system to determine how well the AOA conformed to each best practice. We then used the average of the scores for the best practices in each of four characteristics—well-documented, comprehensive, unbiased, and credible[1]—to determine an overall score for each characteristic. We sent our draft analysis to DOD for review. They provided technical comments and additional documentation that we incorporated to ensure our analysis included all available information. We then used the same methodology and scoring process explained above to revise the analysis based on their technical comments and any additional evidence received. If the average score for each characteristic was "met" or "substantially met," we concluded that the AOA process conformed to best practices and therefore could be considered reliable.[2]

To determine how the increments of ACV are to achieve amphibious capability, we reviewed program documentation from the ACV acquisition, including the acquisition strategy and the Concept of Employment, as well as program documentation for Navy surface connector programs, including the Ship to Shore Connector Capabilities Development Document and the Surface Connector Council charter. We also interviewed USMC officials from the Combat Development and Integration, Capabilities Development Directorate and Seabasing Integration Division, as well as U.S. Navy officials from the Naval Sea Systems Command.

To update and refine the AOA best practices identified in prior GAO work, we solicited comments from a set of over 900 internal and external experts on how to improve the previous set of best practices. All comments and changes were vetted during three vetting sessions with internal GAO experts. The resulting changes include the consolidation of some best practices, reducing the number from 24 to 22, and the establishment of four characteristics that identify a high-quality, reliable AOA process.

[1]Characteristics are defined in appendix I.

[2]The five-point scoring system that we used was as follows: "met" means that USMC's documentation demonstrated that it completely met the best practice; "substantially met" means that USMC's documentation demonstrated that it met a large portion of the best practice; "partially met" means that USMC's documentation demonstrated that it met about half of the best practice; "minimally met" means that the USMC's documentation demonstrated that it met a small portion of the of the best practice; and "did not meet" means that USMC's documentation did not demonstrate that it met the best practice.

Appendix III: Amphibious Combat Vehicle 2014 Analysis of Alternatives Compared with Best Practices

Overall, the DOD's ACV analysis of alternatives (AOA) met the best practices we identified. Table 3 below describes our analysis of DOD's AOA compared with best practices.

Table 3: Amphibious Combat Vehicle Analysis of Alternatives (AOA) Compared with Best Practices

Best practice phase	Best practice	Combined or Individual[a]	Assessment[b]
Initialize the AOA process	1. Define mission need	Combined	Met
	2. Define functional requirements	Combined	Met
	3. Develop AOA timeframe	Individual	Met
	4. Establish AOA team	Individual	Met
	5. Define selection criteria	Individual	Met
	6. Weight selection criteria	Combined	Met
	7. Develop AOA process plan	Combined	Met
Identify alternatives	8. Develop list of alternatives	Combined	Met
	9. Describe alternatives	Combined	Met
	10. Include baseline alternative	Combined	Met
	11. Assess alternatives' viability	Combined	Met
Analyze alternatives	12. Identify significant risks and risk mitigation strategies	Combined	Met
	13. Determine and quantify benefits/effectiveness	Individual	Substantially met: In some cases, comparable mobility analysis data was not available for all alternatives. In addition, the study encountered data consistency issues that were not resolved until after the analysis of alternatives was completed.
	14. Tie benefits/effectiveness to mission need	Combined	Met
	15. Develop life-cycle cost estimates (LCCEs)	Individual	Partially met: The AOA team relied on cost estimating experts to develop a reliable life-cycle cost estimate for each alternative; however, while the cost and affordability analyses use inflation indexes to normalize data, they do not adjust for a nominal discount rate to arrive at a present value in order to account for both potential decreases in purchasing power and the impact of the future value of money.

Best practice phase	Best practice	Combined or Individual[a]	Assessment[b]
	16. Include a confidence interval or range for LCCEs	Individual	Substantially met: While the 2014 AOA study plan presents the overall cost for each alternative with a low, most likely, and high value; none of these analyses display a point estimate with a quantifiable confidence level or associated S-curve.
	17. Perform sensitivity analysis	Individual[c]	Substantially met: Sensitivity analysis was included in the cost analysis, affordability assessment, and some elements of the capability assessments, but it was not performed for all key assumptions in each case.
Document and review the AOA process	18. Document AOA process in a single document	Individual	Substantially Met: The 2014 AOA documented all steps taken for the 2014 analysis and makes reference to previous studies that contributed the analysis, but the full relationship among the analyses is not specified in the 2014 report.
	19. Document assumptions and constraints	Combined	Partially met: The 2014 analysis includes selected documentation of assumptions, but does not include a full list of assumptions, constraints, and justifications. Any relevant assumptions from previous analyses were not referenced in the 2014 report.
	20. Ensure AOA process is impartial	Combined	Met
	21. Perform independent review	Individual	Met
Select a preferred alternative	22. Compare alternatives	Individual	Minimally met: While net present value was not used in the report, agency officials stated that they believed the cash flows and discount rates were such that the impact was minimal.

Source: GAO analysis of USMC information. | GAO-16-22

[a]Best practices labeled “Individual” have been assessed based on only the 2014 ACV Analysis of Alternatives final report. Best practices noted as “Combined” were assessed referring to the full body of work that has informed the analysis of alternatives process, as defined by USMC officials. This body of work includes studies related to the EFV and Advanced Amphibious Assault Vehicle, Marine Personnel Carrier and ACV requirements documents, the 2008 Marine Personnel Carrier AOA, the 2012 ACV AOA, the 2014 ACV AOA, the 2013 ACV Special Project on high water speed, and Systems Engineering Overarching Product Team analysis.

[b]The five-point scoring system that we used was as follows: “met” means that USMC’s documentation demonstrated that it completely met the best practice; “substantially met” means that USMC’s documentation demonstrated that it met a large portion of the best practice; “partially met” means that USMC’s documentation demonstrated that it met about half of the best practice; “minimally met” means that the USMC’s documentation demonstrated that it met a small portion of the best practice; and “did not meet” means that USMC’s documentation did not demonstrate that it met the best practice.

[c]Although this best practice would usually be assessed on an individual basis, the 2014 Amphibious Combat Vehicle AOA report specifically refers to combat scenarios that were performed for the ACV 2012 AOA. As a result, GAO considered the 2012 scenario information to be subsumed into the 2014 analysis and included that work in its review of this best practice.

Table 4 provides the average score of the best practices under each characteristic. See appendix I for an explanation of how individual best practices are grouped under each characteristic. Because the overall assessment ratings for each of the four characteristics are substantially met or met, we concluded that the AOA process conformed to best practices and can be considered reliable.

Table 4: Average Score of Best Practices for each Characteristic

Characteristic	Average Score of Best Practices
Well-documented	Substantially met
Comprehensive	Met
Unbiased	Substantially met
Credible	Met

Source: GAO analysis of USMC information. | GAO-16-22

Appendix IV: Additional Information on Selected Surface Connectors and Key Capabilities

Surface Connector or *Planned Replacement*	Current Quantity or *Planned Quantity*	Water Speed in Knots[a]	Payload Capacity in Short Tons (ST) and in Number of Amphibious Combat Vehicles (ACV)[a,b]	Range in Nautical Miles[a]	Operating Sea State with Significant Wave Height (SWH)[c]
Landing Craft Air Cushion Service Life Extension Program	72	35	60 ST 2 ACV	100	2 (1.0 SWH)
Ship to Shore Connector	*72*	*35*	*74 ST* *2 ACV*	*86*	*3 (4.1 SWH)*
Landing Craft Utility	32	8	125 ST[d] 3 ACV	1200	3
Surface Connector (X) Replacement	*32*	*8*	*170 ST* *3 ACV*	*1200*	*3*
Expeditionary Fast Transport	5 *11*	35	600 ST 19 ACV	1200	3

Source: GAO presentation of US Navy information. | GAO-16-22

[a]The figures provided for each capability are considered maximums for current surface connectors or expected maximums for planned replacement surface connectors. Actual performance or capabilities may differ due to environmental or mission-dependent conditions, such as payload or sea state.

[b]Transport of ACV is ship to shore.

[c]LCAC Capabilities based on 1.0 significant wave height (SWH). Ship to Shore Connector capabilities based on 4.1 SWH. Both the North Atlantic Treaty Organization and World Meteorological Organization sea state tables characterize 1.0 foot SWH as sea state 2 and 4.1 feet SWH as sea state 4. Sea states (SS) are classified on a scale of 0 to 9 depending on the roughness of the water as caused by wind or other disturbances. SS 0 to 3 represent calm to slight seas of 4 feet or less. SS 4 is characterized by moderate seas of 4 to 8 feet. SS 5 to 6 range from rough to very rough seas between 8 to 20 feet. SS 7 to 9—the most challenging marine conditions—reflect high to extremely rough seas, including seas above 20 feet.

[d]All LCU were de-rated from 140 short tons due to corrosion and structural issues caused by advanced craft age.

Appendix V: Comments from the Department of Defense

PRINCIPAL DEPUTY UNDER SECRETARY OF DEFENSE
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WASHINGTON, DC 20301-3015

ACQUISITION, TECHNOLOGY, AND LOGISTICS

OCT 0 9 2015

Ms. Marie A. Mak
Director
Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G Street, N.W.
Washington, DC 20548

Dear Ms. Mak:

This is the Department of Defense response to the Government Accountability Office (GAO) Draft Report, GAO-16-22, "AMPHIBIOUS COMBAT VEHICLE ACQUISITION: Some Acquisition Activities Demonstrate Best Practices; Attainment of Amphibious Capability to be Determined," dated September 16, 2015 (GAO Code 121275). The Department appreciates the effort of the GAO and the opportunity to comment on the draft report.

The report appears to underestimate ACV 1.1's planned technical maturity and associated risks. The proposed vehicles are beyond the traditional Preliminary Design Review (PDR) and Critical Design Review (CDR) level of maturity due to vehicle designs based on fielded systems that are being modified to meet Marine Corps requirement. Conducting a combined PDR/CDR is appropriate for the level of risk identified by the Program Manager and will establish the initial design baseline of the contractor designs that will enter into developmental and operational tests.

We believe our efforts on this program are aligned with GAO's best practices. We will continue to monitor the program and ensure that mitigations are in place to address potential risk areas.

My point of contact for this effort is Mr. John McGough at john.t.mcgough.civ@mail.mil or 703-695-3043.

Alan F. Estevez

Appendix VI: GAO Contact and Staff Acknowledgments

GAO Contact

Marie A. Mak, (202) 512-4841 or makm@gao.gov

Staff Acknowledgments

Key contributors to this report were Bruce H. Thomas, Assistant Director; Betsy Gregory-Hosler, analyst-in-charge; Zachary Sivo; Marie Ahearn; Brian Bothwell; Jennifer Echard; Kristine Hassinger; Katherine Lenane; Jennifer Leotta; David Richards; Karen Richey; Robert S. Swierczek; Hai Tran; and Ozzy Trevino.

(121275)

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