

March 2012

# KC-46 TANKER AIRCRAFT

## Acquisition Plans Have Good Features but Contain Schedule Risk



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#### Why GAO Did This Study

Aerial refueling is essential to global U.S. military operations. The backbone of the nation's tanker forces—the KC-135 Stratotanker—is over 50 years old on average with age-related problems and increasing support costs that could ground the fleet. Given this, the Air Force has initiated the \$51.7 billion KC-46 program to start replacing the current fleet. Plans are to produce 18 tankers by 2017 and 179 aircraft through 2027. Other follow-on procurements are anticipated to replace all KC-135s (see graphic).

The National Defense Authorization Act for Fiscal Year 2012 requires GAO to annually review the KC-46 program through 2017. This report addresses (1) the program's acquisition strategy, including its contracting approach; (2) the major schedule and technical risks; and (3) the extent the program's acquisition strategy and documentation comply with policy, legislation, and best practices. To address these areas, GAO reviewed key documents on the program's contract and cost baseline. GAO discussed the major schedule and technical risks with program office officials and examined an independent technology readiness assessment. GAO also assessed the acquisition plan and required documentation to determine compliance with acquisition legislation, policy, and best practices.

#### What GAO Recommends

GAO recommends DOD leadership monitor the progress and outcomes of this contract to provide lessons learned for future acquisition programs, and the program fully implement metrics to track achievement of key performance parameters. DOD fully concurred.

View [GAO-12-366](#). For more information, contact Michael J. Sullivan at (202) 512-4841, or [sullivanm@gao.gov](mailto:sullivanm@gao.gov).

#### What GAO Found

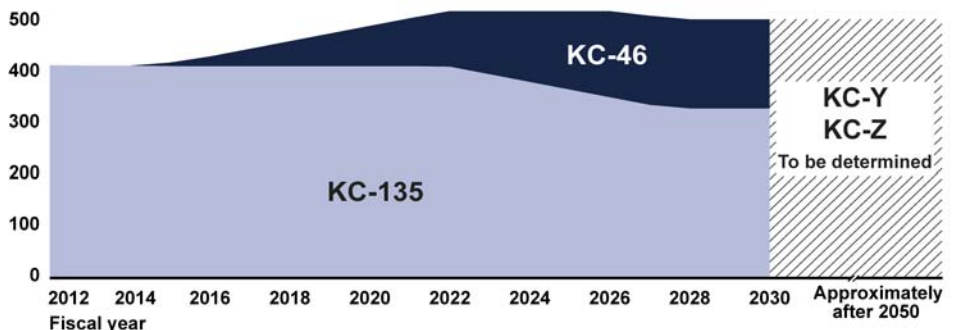
The KC-46 program has established its acquisition strategy for development and production, including total cost, procurement quantities, and key milestone dates. The program is using a \$4.4 billion fixed-price incentive (firm target) development contract that provides contractor incentives to control costs and limits the government's liability for increased costs over a certain amount. While estimated development costs are currently \$900 million higher than the February 2011 contract award amount, the government's share of these extra costs is limited to about \$500 million. The program has identified key performance parameters, but has not yet fully implemented the metrics for tracking their achievement.

There is broad agreement that KC-46 schedule risk is a concern. In GAO's assessment, significant concurrency, or overlap, among development and production activities add risk to the program. The Air Force and contractor have assessed overall schedule risk as moderate, citing concerns about software and the ability to complete development flight testing on time. Further, the DOD's chief testing official finds the testing schedule not executable as currently planned. While designing a new tanker using a modified commercial platform is not as technically challenging as a more revolutionary weapon system, the program still faces some technical risks, including technologies that have not yet been demonstrated during flight.

The KC-46 program's acquisition strategy provides a good framework for meeting GAO's knowledge-based best practices, and generally adheres to defense policy guidance and recent acquisition reform legislation. DOD waived the requirement for a preliminary design review before the program began system development and demonstration, but this design review is planned for March 2012. Although the program's three critical technologies have not yet achieved the level of maturity indicated in best practices, they have reached a level of maturity consistent with DOD policy. Given that the KC-46 is one of only a few major programs in recent years to use a fixed-price incentive contract and the importance of tanker replacement to national security, rigorous monitoring of the program's progress will be essential.

**Notional Representation of Air Force Plans to Replace Tanker Fleet**

Number of aircraft



Source: GAO presentation of Air Force data.

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**Abbreviations**

CAPE	Cost Assessment and Program Evaluation
DOT&E	Director, Operational Test & Evaluation
DOD	Department of Defense
EMD	Engineering and Manufacturing Development
FAA	Federal Aviation Administration
ICE	Independent Cost Estimate
KPP	Key Performance Parameters
OSD	Office of the Secretary of Defense
SCP	Service Cost Position

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United States Government Accountability Office  
Washington, DC 20548

March 26, 2012

### Congressional Committees

Aerial refueling—the transfer of fuel from an airborne tanker to a receiving aircraft—is critical to global U.S. military operations, allowing its aircraft to fly further, stay airborne longer, and carry more weapons, equipment, and supplies. According to the Air Force, the national security strategy cannot be executed without aerial refueling. Military operations in Iraq and Afghanistan during the last decade depended on tankers to get the military’s fighters, bombers, and airlifters to the Middle East and operate while there. That said, the backbone of the U.S. large tanker fleet, the KC-135 Stratotanker, is over 50 years old on average and costing increasingly more to maintain and support. In 2004, we reported on Department of Defense (DOD) concerns that age-related problems could potentially ground the aerial refueling fleet and cripple support to combat forces.<sup>1</sup> In February 2011, the Air Force awarded a contract that began a \$51.7 billion effort to replace its fleet by starting the KC-46 program.<sup>2</sup> The Air Force plans to develop, test, and procure 18 KC-46 tankers by 2017, and then go on to procure a total of 179 aircraft to replace about two-fifths of the KC-135 fleet.

The National Defense Authorization Act for Fiscal Year 2012 requires that we review the KC-46 program and report by March 1 each year, ending in 2017.<sup>3</sup> In response, this report examines (1) the program’s acquisition strategy, including its contracting approach; (2) the major schedule and technical risks faced by the program; and (3) the extent to which the program’s acquisition strategy and documentation comply with DOD acquisition policy, legislation, and commercial best practices. To address these areas, we reviewed key documents outlining key aspects of the program’s acquisition strategy. We also discussed the major program schedule and technical risks with program office officials and examined

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<sup>1</sup>GAO, *Military Aircraft: DOD Needs to Determine Its Aerial Refueling Aircraft Requirements*, [GAO-04-349](#) (Washington, D.C.: June 4, 2004).

<sup>2</sup>The KC-46 designation refers to the acquisition program, while the designation for the actual tanker aircraft being procured is the KC-46A. However, for purposes of this report, we will use the KC-46 designation throughout.

<sup>3</sup>Pub. L. No. 112-81, § 244.

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an independent technology readiness assessment. We also reviewed the program's acquisition plan and required documentation to determine the extent it complied with relevant acquisition legislation, policy, and best practices. We conducted this performance audit from September 2011 to March 2012 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. See appendix I for more information on our scope and methodology.

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## Background

While several types of aircraft provide aerial refueling services, the principal effort is currently carried out by the Air Force fleet of 414 KC-135 aircraft. Originally fielded in the 1950s, KC-135 aircraft are considered the mainstay of the tanker fleet, supporting combat air assets, deployment of airlift aircraft, and nuclear combat refueling missions. With an average age of nearly 51 years and more than 16,000 flight hours on each aircraft, the KC-135s will approach over 80 years of age when the fleet is retired as projected in the 2040 time frame. In 1981, the Air Force began supplementing its fleet of KC-135s with the procurement of 60 KC-10s (of which 59 remain in service today), multi-role aircraft that transport air cargo and provide refueling. Much larger than the KC-135, the KC-10 provides both boom and hose and drogue refueling capabilities<sup>4</sup> on the same flight and can conduct transoceanic missions. The KC-10s now average about 27 years of age with more than 26,000 flight hours on each, and their service life is expected to end around 2045. The Air Force has upgraded and modified both fleets in recent years, providing improved avionics and new engines on the KC-135 along with newer communication systems to comply with international and federal air traffic requirements.

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<sup>4</sup>Currently, Air Force fixed-wing aircraft refuel with the "flying boom." The boom is a rigid, telescoping tube that an operator on the tanker aircraft extends and inserts into a receptacle on the aircraft being refueled. Air Force helicopters, and all Navy and Marine Corps aircraft refuel using the "hose and drogue." The "hose and drogue" system involves a long, flexible refueling hose stabilized by a drogue (a small windsock) at the end of the hose.

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In 1996, GAO reported that the aging KC-135s would eventually need to be replaced.<sup>5</sup> We recommended that DOD consider looking at dual-use aircraft—which could be used as a tanker or a cargo carrier, depending on their missions. In 2001, the Air Force reported that the KC-135 fleet would incur much greater operations and maintenance (O&M) costs between 2001 and 2040, but that it would be structurally sound to 2040.<sup>6</sup> Air Force officials stated in 2005 that engine strut fatigue caused by long-term heat exposure and corrosion posed the greatest threat to the KC-135 fleet and O&M costs were increasing. These costs, nearly \$2 billion in fiscal year 2010, are expected to grow to \$6 billion per year by fiscal year 2018. The 2012 Air Mobility Master Plan also expresses concerns that advanced adversary threats pose greater risk to the current tanker fleet and that the KC-135 fleet lacks defensive capabilities required to operate and succeed against either current or future threats.

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## Tanker Replacement History

Plans to begin replacing the KC-135 fleet were first developed in 2001 with Congress authorizing a pilot program to lease 100 Boeing 767 aircraft modified for aerial refueling, subsequently called the KC-767A aircraft.<sup>7</sup> This leasing deal was ultimately canceled, however, after a DOD investigation found that a senior Air Force official improperly approved the leasing deal.

After the canceled tanker leasing deal, an Analysis of Alternatives (AOA)<sup>8</sup> was conducted which determined that use of a tanker based on a commercial aircraft would be the most cost-effective way to replace the Air Force's aging fleet of KC-135s. In January 2007, DOD issued a request for proposal (RFP)<sup>9</sup> to procure 179 such tankers. On February

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<sup>5</sup>GAO, *U.S. Combat Air Power: Aging Refueling Aircraft Are Costly to Maintain and Operate*, [GAO/NSIAD-96-160](#) (Washington, D.C.: Aug. 8, 1996).

<sup>6</sup>"KC-135 Economic Service Life Study," Technical Report F34601-96-C-0111, Feb. 9, 2001.

<sup>7</sup>Pub. L. No. 107-117, § 8159.

<sup>8</sup>The AOA is an important element of the defense acquisition process. An AOA is an analytical comparison of the operational effectiveness, suitability, and life-cycle cost (or total ownership cost, if applicable) of alternatives that satisfy established capability needs. Defense Acquisition Guidebook, 3.3.1.

<sup>9</sup>The Federal Acquisition Regulation (FAR) provides for the use of RFPs in negotiated acquisitions to communicate government requirements to prospective contractors and to solicit proposals. FAR § 15.203(a).

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29, 2008, the Air Force awarded the first contract of a three-phased approach, called the KC-45, to a partnership between Northrop Grumman and the European Aeronautic Defence and Space Company (EADS) to build four aircraft for testing and then manufacture 175 production aircraft. Boeing, the competing bidder, filed a protest with the Government Accountability Office (GAO) protesting the Air Force's decision. In June 2008, GAO determined that the Air Force had made significant errors, including not assessing the relative merits of the proposals in accordance with the evaluation rules and criteria set out in the RFP, which could have affected the outcome of the competition.<sup>10</sup> As a result, the Office of the Secretary of Defense (OSD) directed the Air Force in September 2008 to terminate the contract and conduct a new competition.

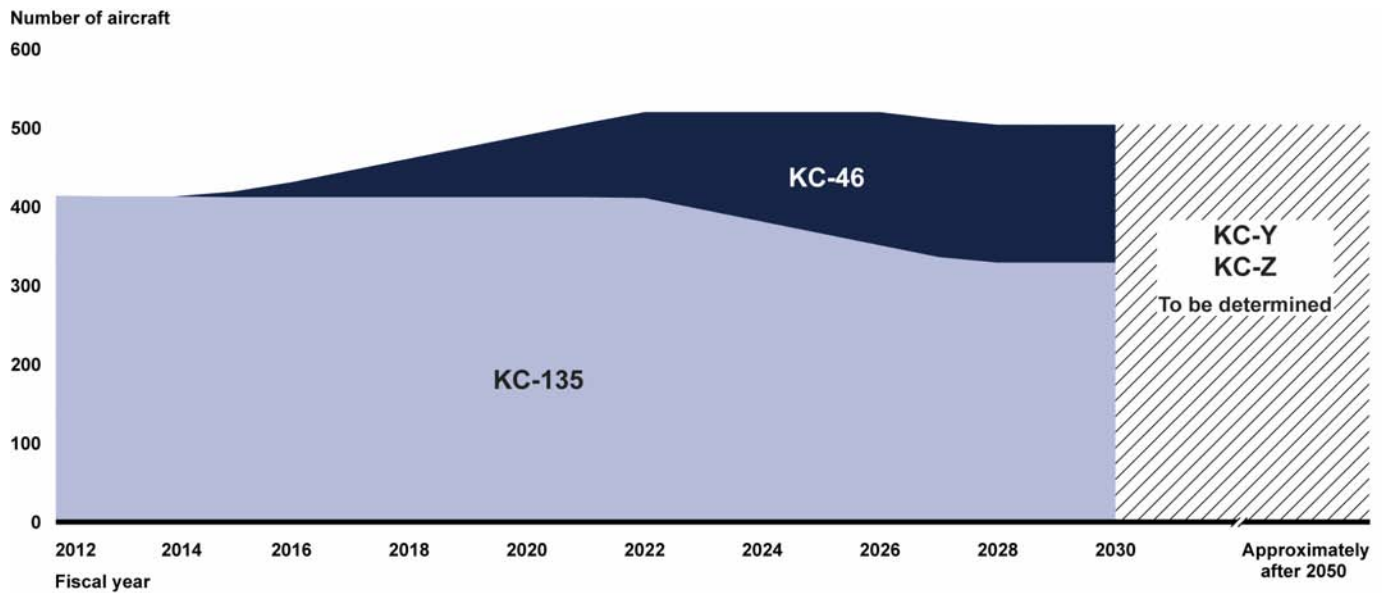
On February 24, 2010, the Air Force released a significantly revised KC-X RFP. One year later, Boeing won the new competition to develop and build 179 new KC-46s at an estimated cost of \$51.7 billion. The development portion of the contract to design and build 4 test aircraft, and then bring those aircraft to a final production configuration, is valued at \$4.4 billion. The Air Force plans to exercise two contract options for 19 initial production aircraft that are required, in part, for the contractor to meet the requirement to produce and deliver 18 aircraft by 2017. Additional contract options can be exercised to allow for production of the remaining 156 aircraft through year 2027 at a target rate of 15 aircraft per year. Separate competitions are planned for later acquisitions, called the KC-Y and KC-Z phases, to replace the rest of the KC-135 fleet. Figure 1 below depicts a notional schedule of how the Air Force plans to replace its current KC-135s over the next several decades.

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<sup>10</sup>The Boeing Company, B-311344 et al., June 18, 2008, 2008 CPD ¶ 114.



**Figure 1: Notional Representation of Plan for Air Force Tanker Fleet Replacement**



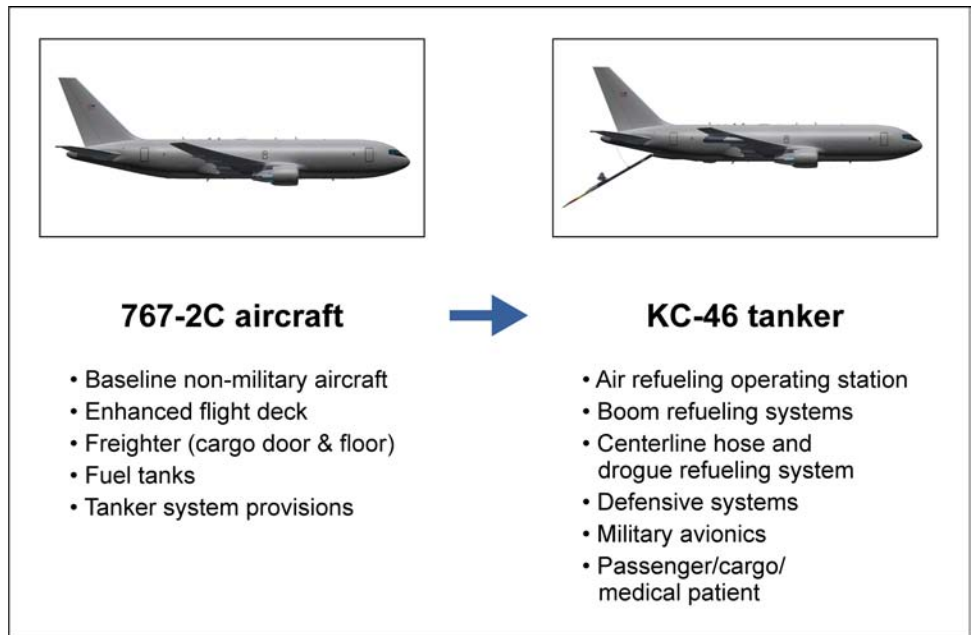
Source: GAO presentation of Air Force data.

Note: KC-46 build-up represents planned production quantities, not planned deliveries and does not include four development test aircraft.

## KC-46 Program

The KC-46 program is planning to turn a Boeing commercial aircraft (the 767-2C) into a militarized KC-46 tanker that is more capable than the KC-135. Boeing is currently developing the 767-2C, which is based on a Boeing 767 model airframe modified to include a cargo door, new fuel tanks and an advanced flight deck display borrowed from the new Boeing 787 aircraft. Militarization of this airframe includes the addition of the refueling boom, centerline drogue system with wing refueling pods, a remote air refueling operator station that includes panoramic three-dimensional displays and threat detection and avoidance systems using advanced software to automatically re-route the aircraft away from threats. Program officials consider the integration of military hardware and software on a commercial platform to be the primary technical risk. Figure 2 below shows the intended conversion of the 767-2C into the KC-46 aerial refueling tanker.

**Figure 2: Conversion of Boeing 767-2C into KC-46 Aerial Refueling Tanker**



Sources: GAO presentation of Air Force information (data); © 2012 Boeing Company (images).

The new tanker is also planned to have several capabilities that existing KC-135s do not have. For example, the KC-46 is expected to be able to refuel in a variety of night-time settings, including covert (not easily visible) mode which the KC-135 cannot do. In addition, it is intended to have countermeasures which protect large aircraft from infrared missile threats. The KC-46 fleet will also have more aircraft with the capability to refuel two aircraft at the same time, with the entire fleet able to conduct this mission, and the ability to carry more cargo, passengers, and medical patients. Table 1 compares the current capabilities of the KC-135 with the planned capabilities of the new KC-46 tanker. (More detail on the planned capabilities is included in appendix II.)

**Table 1: Comparison of Current KC-135 versus Planned KC-46 Performance Capabilities**

Key capability	KC-135	KC-46
Primary function	Aerial refueling and airlift with 200,000 lbs. total fuel for refueling	Aerial refueling and airlift with 207,672 lbs. total fuel for refueling
Boom refueling	Hydraulic system with 1,176 gallons per minute refueling rate	Computer assisted with 1,200 gallons per minute refueling rate
Hose and drogue refueling	Permanent system does not exist—must be temporarily added	Permanent centerline hose and drogue system
Refueling of two aircraft at the same time	Limited to 20 tankers with the capability to attach wing pods and conduct multipoint refueling of two aircraft	All tankers have the capability to attach wing pods and conduct multipoint refueling, but only 46 sets of wing pods will be procured
Cargo/passenger/medical patient	6 cargo pallets, 53 passengers, 44 medical patients	18 cargo pallets, 114 passengers, 58 medical patients
Defensive systems	Does not possess sufficient systems	Protection from nuclear, infrared (heat seeking missiles), and biochemical threats
Night-time refueling	Restricted in tactical missions	Able to refuel in tactical missions

Source: GAO presentation of Air Force data.

## KC-46 Program Has Established Its Acquisition Strategy

The KC-46 program has established its acquisition strategy for aircraft development and production, which includes a total cost estimate of \$51.7 billion, aircraft quantities to be procured, key milestone dates, and test and manufacturing schedules. The KC-46 program is using a fixed-price contract for development, designed to provide a profit incentive for the contractor to control costs, while limiting government liability for increased costs over a certain amount. The program has also identified nine key performance parameters (KPP) critical to enabling the KC-46 to meet mission requirements, but has not yet fully implemented metrics that will be used to track the achievement of these KPPs.

## KC-46 Approval of Baseline Cost, Schedule, and Aircraft Quantities

In February 2011, senior defense leaders approved the KC-46 program's entry into the acquisition process at the Engineering and Manufacturing Development (EMD) phase (called Milestone B). Table 2 summarizes planned quantities, costs, and milestone dates approved at that time.

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**Table 2: Approved KC-46 Quantities, Cost, and Schedule**

<b>Expected quantities</b>	
Development quantities	4
Procurement quantities	175
<b>Total quantities</b>	<b>179</b>

<b>Cost estimates (then-year dollars in millions)</b>	
Development	\$7,149.6
Procurement	\$40,236.0
Military Construction	\$4,314.6
<b>Total program acquisition</b>	<b>\$51,700.2</b>

<b>Unit cost estimates (then-year dollars in millions)</b>	
Average program acquisition	\$288.8
Average procurement	\$229.9

<b>Key milestones</b>	
Program contract award (Milestone B)	February 2011
Low rate initial production (Milestone C)	August 2015
Initial operational test and evaluation start	May 2016
Full rate production decision	June 2017
Required assets available (18 aircraft operationally ready)	August 2017

Source: GAO presentation of Air Force data.

Defense officials established a total acquisition program baseline cost of \$51.7 billion. The development cost estimate of \$7.1 billion includes \$5.3 billion for the development contract and \$1.8 billion for other costs, including air crew and maintenance training systems, operational testing, and program office support. The procurement cost estimate of \$40.2 billion is based on projected prices for procuring 175 aircraft in annual quantities of up to 15 aircraft through fiscal year 2027. At this price, aircraft would cost almost \$230 million on average. Military construction costs to build hangars, maintenance and supply shops, and other facilities to house and support the KC-46 fleet are estimated at \$4.3 billion. Following a successful initial production decision, the Air Force plans to exercise the first two production contract options. After the options are exercised, Boeing will be required to provide the Air Force with a total of 18 operationally ready aircraft 78 months after development contract

award, which would be by August 2017.<sup>11</sup> Further contract options are planned to continue through 2027, until a total of 179 aircraft are bought.

**Development Contract Includes Features to Control Cost, Schedule, and Performance Risk**

In February 2011, the Air Force awarded Boeing a fixed-price contract to develop, test, and manufacture four KC-46 aircraft. The specific contract arrangement used by the KC-46 program is a fixed-price incentive (firm target) (FPIF) contract. Table 3 provides development contract details and the current contract and government estimates to complete development.

**Table 3: KC-46 Development Contract Values and Current Estimates**

Dollars in millions			
		FPIF contract line items	Total contract <sup>a</sup>
Contract amounts	Target price	\$4,327.3	\$4,393.9
	Ceiling price	\$4,831.0	\$4,897.6
Current estimates by:	Contractor	\$5,096.9	\$5,163.5
	Government	\$5,284.4	\$5,351.0

Source: KC-46 Selected Acquisition Report, the Federal Procurement Data System – Next Generation, and GAO calculations.

<sup>a</sup>Total contract amounts are different from FPIF amounts because they include two firm fixed price contract line items, one for technical data license rights and one for testing.

The contract is designed to provide a profit incentive for the contractor to control or even reduce costs. It specifies target cost, target price, and ceiling price amounts, with the latter being the maximum amount that may be paid to the contractor. The target price is \$4.4 billion and the ceiling price \$4.9 billion. The contract specifies a 60/40 incentive ratio for sharing savings in the event of underruns, or sharing cost in the event of overruns. The government’s share is 60 percent while Boeing’s is 40 percent. Cost sharing ends when the contract price reaches the \$4.9 billion ceiling. Thereafter, provided the Air Force is not responsible for any of the additional costs associated with the overruns, the contractor would be responsible for all additional costs associated with the overruns and would be obligated to perform the contract. If the Air Force is responsible

<sup>11</sup> According to program officials, the government will hold Boeing accountable to the terms and conditions of the contract and seek consideration from Boeing if they do not perform to the contract requirements.

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for any of the cost overruns, they may have to renegotiate the terms and conditions of the contract with Boeing. The KC-46 program's current government estimate to complete development is \$5.3 billion, which is about \$900 million more than the contract target price and about \$400 million more than the ceiling price. The Air Force believes this additional \$400 million may be necessary to cover schedule risk for the remainder of development, and if it is, Boeing must pay these costs.

According to program officials, a change in system requirements, although unlikely, would be a circumstance that could increase the Air Force's exposure to additional costs. As stated in a memorandum from the OSD Office of Cost Assessment and Program Evaluation,<sup>12</sup> the biggest risk to the KC-46 program is the Department's ability to minimize changes to the contract. The memorandum maintains that on the whole, DOD has demonstrated limited ability to maintain stable requirements and limit changes to program technical baselines on previous complex weapon system programs, and that minimizing such change is essential to the success of the KC-46. In view of these concerns, program officials state it is very unlikely any requirements will be changed, and to help ensure this, they have instituted a process to control changes. Specifically, any engineering or contract changes affecting system requirements or having the potential to impact program cost, schedule, and performance baselines must be approved by the Air Force Service Acquisition Executive in consultation with the Secretary and the Chief of Staff of the Air Force. Moreover, the contract contains options for the 175 production aircraft, establishing firm, fixed pricing for two initial production lots and not-to-exceed pricing for subsequent full-rate production lots. Program officials maintain that this pricing will likely stay intact as long as the contract is not opened to negotiate modifications.

The KC-46 contract is one of only a few major weapon system programs in recent years to employ a fixed-price development contract. In the past, DOD has typically used cost-reimbursement contracts in which the government pays all allowable incurred costs to the extent prescribed by the contract. Legislation and defense policy now directs the Milestone Decision Authority for a major defense acquisition program to select the contract type for a development program at the time of a decision on

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<sup>12</sup>The Office of Cost Assessment and Program Evaluation provide independent cost estimates for major DOD weapon system programs.

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Milestone B that is consistent with the level of program risk for the program. The Milestone Decision Authority may select either a fixed-price type contract (including a fixed-price incentive contract); or a cost type contract. The use of fixed-price contracts, when warranted, limits the government's exposure to weapon system cost increases. Defense officials believe that a fixed-price development contract is appropriate for this program because KC-46 development is considered to be a relatively low risk effort to integrate mature military technologies onto a well-defined commercial derivative aircraft.

In addition to the type of contract used, there are also provisions in the KC-46 development contract that further limit the government's liability and are intended to help manage performance risk. For example, Boeing has to correct any deficiencies in the KC-46 discovered during the development program. The correction of deficiencies shall be accomplished on the four development test aircraft and all production aircraft, as appropriate, to bring them to the final configuration at no additional cost to the government. In addition, there is a special contract provision that requires each aircraft to demonstrate a certain fuel usage rate before the government accepts the aircraft. If any aircraft burn fuel above this rate, Boeing is required to propose a corrective action at no cost to the government. Boeing is not allowed to propose a relaxation of contract requirements to resolve any fuel usage issues, but if Boeing cannot meet the required usage rates, there are contract provisions allowing for a decrease in the amount paid to Boeing.

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**Key Performance Goals Have Been Identified but Metrics for Measuring Achievement Are Not Yet Fully Implemented**

The Air Force has identified nine specific KPPs critical to enabling the KC-46 to meet its primary mission of providing worldwide, day and night, adverse weather aerial refueling. Several of these parameters have been established to address performance characteristics that are limited or nonexistent in the current tanker fleet. For example, in 2005 only 8 KC-135 aircraft (1.5 percent) had the capability to receive fuel from another aerial refueling tanker while airborne. This limited capability can prohibit the extension of aircraft forces and can result in inefficient use of assets. By establishing a KPP to allow for the KC-46 fleet to receive fuel from other tankers, the Air Force hopes to address this shortcoming. Table 4 describes the planned KC-46 KPPs.

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**Table 4: Description of KC-46 Key Performance Parameters**

<b>Key performance parameter</b>	<b>Description</b>
Tanker air refueling capability	Aircraft shall be capable of accomplishing air refueling of all DOD current and programmed (budgeted) receiver aircraft. The aircraft shall be capable of conducting both boom and drogue air refueling on the same mission.
Fuel offload versus radius	Aircraft shall be capable of carrying certain amounts of fuel (to use in air refueling) certain distances.
Operate in civil and military airspace	Aircraft shall be capable of worldwide flight operations in all civil and military airspace.
Airlift capability	Aircraft shall be capable of transporting certain amounts of both equipment and personnel.
Receiver air refueling capability	Aircraft shall be capable of receiving air refueling from any compatible tanker aircraft.
Force protection	Aircraft shall be able to operate in chemical and biological environments.
Net-ready	Aircraft must be able to have effective information exchanges with many other DOD systems to fully support execution of all necessary missions and activities.
Survivability	Aircraft shall be capable of operating in hostile threat environments.
Simultaneous multi-point refueling	Aircraft shall be capable of conducting simultaneous drogue refueling on multiple aircraft.

Source: GAO presentation of Air Force data.

Near the end of KC-46 development, a series of independent tests and evaluations are planned to validate whether the aircraft meets these KPPs. However, the Air Force still has to fully implement the specific metrics needed to measure progress against the KPPs. In future reports, we will include an evaluation of metrics established for each of these KPPs as well as whether the program is on track to meet them.

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## Key Events in Program Schedule Are Concurrent and Technical Challenges Exist

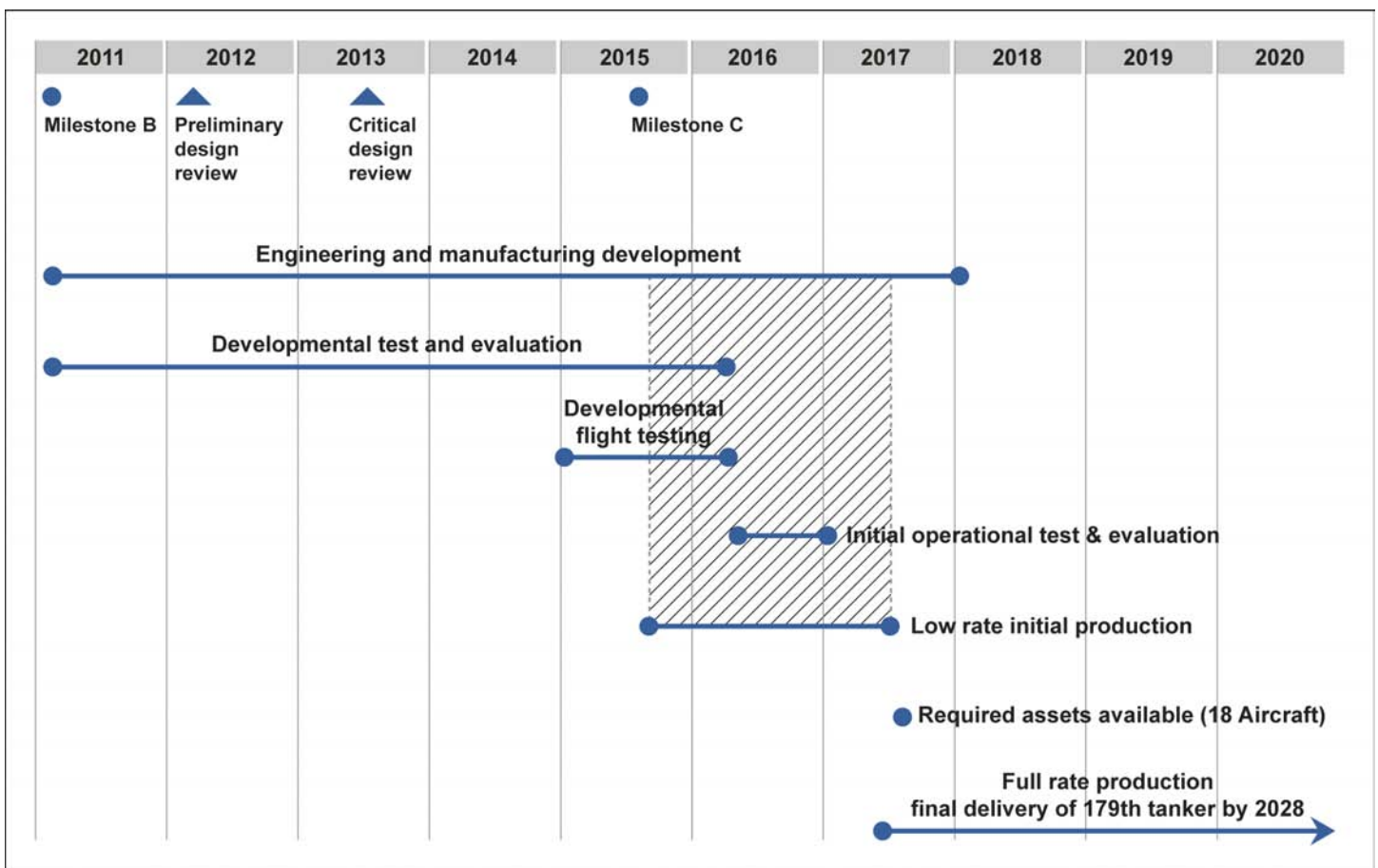
Schedule risk on the KC-46 program is a concern and technical challenges will need to be overcome. The program has an accelerated schedule with significant overlap, or concurrency, among the development, testing, and production of initial aircraft. Also, while designing a new tanker that uses a modified commercial platform may not be as technically challenging as an all new weapon system, the program still faces some technical risks, including three critical technologies that have not yet been tested in a realistic environment.




## Significant Concurrency Poses Risks to KC-46 Development and Production Schedule

The significant amount of concurrency in the KC-46 schedule among planned development, testing, and production activities are highlighted by the shaded area in figure 3.

Figure 3: Planned KC-46 Program Concurrency between Development and Production



 Period of concurrency

Source: GAO presentation of Air Force data.

The decision to begin low-rate initial production is scheduled for August 2015, before significant development and testing activities are completed. While about 6 months of 767-2C flight testing is planned to be conducted prior to KC-46 flight testing to help prove the aircraft's design and flying

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qualities, only about 60 percent of the dedicated KC-46 development flight testing is planned to be completed by the start of low-rate initial production, when the Air Force estimates \$1.38 billion will be needed for seven aircraft. Funding commitments will be required even sooner; DOD will present the budget request for KC-46 initial production to Congress in February 2014.

The intent of development flight testing is to demonstrate the maturity of the design and to discover and fix design and performance problems while the aircraft is being developed. Beginning production before testing has successfully demonstrated that the design is mature and that aircraft will work as intended increases the likelihood of discovering deficiencies during production, when it is most expensive to correct them. Similarly, systems already built and fielded may require substantial modifications, resulting in additional program costs.

The Air Force and Boeing are both concerned about the risks in the KC-46 development and test schedule. In August 2011, a joint Boeing and Air Force team completed a detailed review to identify risk associated with the program's technology, cost, and schedule. As a result of that review, the Air Force determined that the schedule, culminating with the delivery of 18 aircraft by August 2017, contained moderate risk.<sup>13</sup> Other major areas examined during this review were assessed as low risk.

According to the KC-46 program office, schedule risk stems from four primary factors:

- **Flight testing.** Completing the flight test program on time will require efficient, synchronized use of DOD, Air Force, and Federal Aviation Administration (FAA) test facilities and resources. The KC-46 program office is concerned that Boeing will not be able to achieve planned flight test flying hour rates for military certifications and military testing, currently set at 50 hours per aircraft per month, given the amount of coordination and synchronization of test resources required. Boeing is also continuing to evaluate plans for the flight test program due to concerns it may contribute to program schedule risk. For these and other reasons, DOD's Office of the Director, Operational Test and

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<sup>13</sup>The delivery of these aircraft must be accompanied by all the required training equipment, support equipment, and the support necessary for their sustainment.

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Evaluation, has determined that the development test program is not executable as planned.

- **In-line provisioning.** Boeing typically uses one facility as its commercial aircraft production line and another to install military modifications on commercial aircraft. However, on the KC-46 program, Boeing will do extra preparatory work—provisioning—at its commercial facility to accommodate the military modifications planned at its other facility. This represents an additional requirement to prepare the aircraft for military modifications while still on the commercial production line. According to the program office, this increases the level of risk for accomplishing the work on time.
- **Federal Aviation Administration certification.** According to the program office, two FAA certifications, one for the commercial 767-2C aircraft and a supplemental one for the military modifications planned for the commercial aircraft, are required for the KC-46 before it is deemed airworthy. Boeing intends to accomplish a portion of both of these certifications concurrently, rather than one at a time, which is more typical. According to the program office, if problems arise during this concurrency, not much time will be left in the schedule for Boeing to recover.
- **Software.** The program office told us that modifications to commercial software to separate classified from unclassified information and enable other military capabilities will increase risk associated with software development. However, they also stated that they are focusing on software early in the program to ensure Boeing puts the proper emphasis on this area and keeps the program schedule on track.

Boeing has also identified risks in the program's software development effort that could delay the program's schedule or drive increased cost if realized. Software development growth can occur because of bad estimates, poor requirements, and poor execution of the software development plan. If the amount of software being developed grows, more staff and more time will be needed. There can also be delays in the integration of hardware and software if software deliveries from suppliers are late. Late delivery can result in hardware and software not being integrated in time to support flight testing, which in turn can mean flight test schedule delays.

A further complication to the KC-46 schedule was Boeing's January 2012 announcement that it was closing its Wichita, Kansas finishing facility at the end of 2013. When the contract was awarded, Boeing had planned to militarize the KC-46 at the Wichita facility. Now, that work will be moving to the Puget Sound facility in Seattle, Washington to be co-located with

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the 767-2C development effort. KC-46 program officials stated that they are working closely with Boeing to understand the impact of this decision on the KC-46 program but will hold Boeing to its contractual delivery date of August 2017.

If the provisions in the current contract remain intact, the government's cost liability will be safeguarded should any of the foregoing risks materialize into problems. However, these provisions cannot prevent delays in delivering aircraft should problems be discovered late in development or while production is underway.

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### KC-46 Will Have Some Risk Stemming from New Technical Content

While a tanker largely based on a commercial platform and subsystems may not be as technically challenging as developing a wholly new weapon system like the Joint Strike Fighter, DOD regulations still require requisite critical technologies to be sufficiently mature prior to starting system development in order to minimize technology risk down the road. As required by DOD policy, a technology readiness assessment was conducted by an independent team of subject matter experts. Overall, the team reviewed and assessed 36 technologies and determined that three are new or novel and are needed for the KC-46 tanker to meet performance and mission capabilities. These three technologies—3-Dimensional Display, Airborne ESTAR, and Threat Correlation Software—have been demonstrated in a relevant environment<sup>14</sup> in accordance with DOD and statutory requirements.<sup>15</sup>

- **Three-Dimensional Display.** The display screens at boom operator stations inside the KC-46 aircraft provide the visual cues needed for the operator to monitor the aircraft being refueled before and after contact with the refueling boom or drogue. The images of the aircraft on the screens are captured by a pair of cameras outside that aircraft that are meant to replicate the binocular aspect of human vision by supplying an image from two separate points of view, replicating how

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<sup>14</sup>GAO has previously defined technology readiness level 6 to mean that a model or prototype close to final form, fit and function has been tested in a high fidelity laboratory environment or in a simulated operational environment. GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs, Appendix III*, [GAO-09-326SP](#) (Washington, D.C.: March 2009).

<sup>15</sup>10 U.S.C. Section 2366b(a)(3)(D); Department of Defense Instruction 5000.02, Operation of the Defense Acquisition System, enc. 2, para. 5.d. (4) (Dec. 8, 2008).

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humans see two points of view, one for each eye. The resulting image separation provides the boom operator with greater fidelity and a more realistic impression of depth, or a third dimension. Similar technology has been used on two foreign-operated refueling aircraft and a representative model in tests with other Boeing tankers.

- **Airborne ESTAR.** This software module is planned to have an algorithm that allows for automatically re-routing and constructing new flight paths for the aircraft that are safe, flyable, and avoid potential threats. The algorithm is new and novel technology, critical to meeting operational requirements. Airborne ESTAR has been tested in a simulation that provided data on its performance, interfaces, and functionality.
- **Threat Correlation Software.** Somewhat similar to Airborne ESTAR, this new software module serves to correlate tracks from multiple potential threats and automatically help re-route the tanker's flight path to avoid them.

These technologies have not yet been demonstrated in a realistic environment, a higher level of maturity that is a best practice.<sup>16</sup> We have previously reported that programs that began development with technologies demonstrated to this level experienced less cost growth than programs with less mature technologies.<sup>17</sup> To the extent that alternatives or workarounds are available for any of the KC-46's technologies, these risks would be mitigated.

In addition to the critical technologies identified, the KC-46 program office identified other integration and technical areas where management will need to focus efforts to mitigate risk. The program office identified the following three areas as being among the more significant:

- **Radar Warning Receiver integration.** A radar warning receiver warns a pilot that a threat aircraft's radar is tracking the KC-46, but

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<sup>16</sup>GAO has previously defined technology readiness level 7 to mean that an actual system prototype has been integrated with key supporting subsystems to demonstrate full functionality and flight-tested in a realistic operational environment. GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs, Appendix III*, [GAO-09-326SP](#) (Washington, D.C.: March 2009). Our extensive body of work in commercial best practices suggests that this higher standard be attained for each critical technology before a new acquisition enters system development.

<sup>17</sup>GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, [GAO-11-233SP](#) (Washington, D.C.: Mar. 29, 2011).

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integrating such a receiver on a large commercial airframe can be challenging. Integration requires a unique antenna design and certain provisions for installation to maximize performance. Any late changes to the location of the receiver's antennae or software could drive cost and schedule impacts to the program.

- **Wing Aerial Refueling Pod instability.** Based on lessons learned from another Boeing refueling aircraft, a new aerial refueling pod design was introduced for the KC-46 to reduce buffeting, or instability, of the aircraft's wing. The new design also made changes to the way the refueling hose exits the pod, so now there is concern about the hose not being stable. If the new wing pod design has technical shortcomings and introduces hose stability issues, this would not meet program requirements.
- **Aircraft Weight.** The current aircraft weight forecast is near the aircraft's weight limit and, historically, weight continues to increase during a weapon system program development phase. Not achieving the target weight will make the aircraft unable to carry the required amount of fuel for its aerial refueling mission.

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## With Some Exceptions, the Program's Development Strategy Generally Adheres to Best Practices, Acquisition Reform Legislation, and DOD Policy

The KC-46 program's acquisition strategy and business case generally meet GAO's knowledge-based acquisition approach and best acquisition practices, including those in legislation to improve the weapon system acquisition process. Also, the contents of the program's requirements documentation generally comply with DOD guidance. However, the program did not conform to best practices in a few instances. The program did not conduct a technology development phase and instead proceeded directly to the system development phase, and our prior work has shown that programs proceeding directly to a development phase typically have more problems. The program also received a waiver from having to conduct a preliminary design review, considered important to initially solidifying the aircraft's design, before beginning development. Instead, the design review is planned for March 2012, about a year after the start of development.

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## Program Is Generally Implementing Acquisition Best Practices

For the most part, the KC-46 program's acquisition framework and plans compare favorably with the standards and requirements in GAO's best practices work on weapon system acquisition development. The program's Acquisition Strategy<sup>18</sup> establishes the decision points and acquisition phases planned for the program. It also covers development, testing, production, and life-cycle support and establishes the requirements for each phase, and also identifies critical management events and risks including integration of military hardware and software on the KC-46 airframe. The program's Integrated Baseline Review (IBR)<sup>19</sup> resulted in a mutual understanding between the KC-46 program office and Boeing ensuring all system capabilities are understood and program requirements are flowed down to the contractor and suppliers. A comprehensive risk assessment also identified all program risks, and assigned moderate risk to the program's development schedule.

The program is also starting to establish a knowledge-based acquisition approach, in which knowledge of various components of the process is acquired at key decision points before proceeding. Our best practices model helps decision makers to be reasonably certain about their products at critical junctures during development and to make informed investment decisions. This knowledge-based process can be broken down into three cumulative knowledge points.

- **Knowledge point 1:** A match must be made between the customer's needs and the developer's available resources—technology, engineering knowledge, time, and funding—before a program starts.
- **Knowledge point 2:** The product's design must be stable and must meet performance requirements before initial manufacturing begins.
- **Knowledge point 3:** The product must be able to be produced within cost, schedule, and quality targets and demonstrated to be reliable before production begins.

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<sup>18</sup>The Acquisition Strategy is a comprehensive, integrated plan that identifies the acquisition approach, and describes the business, technical, and support strategies that management will follow to manage program risks and meet program objectives.

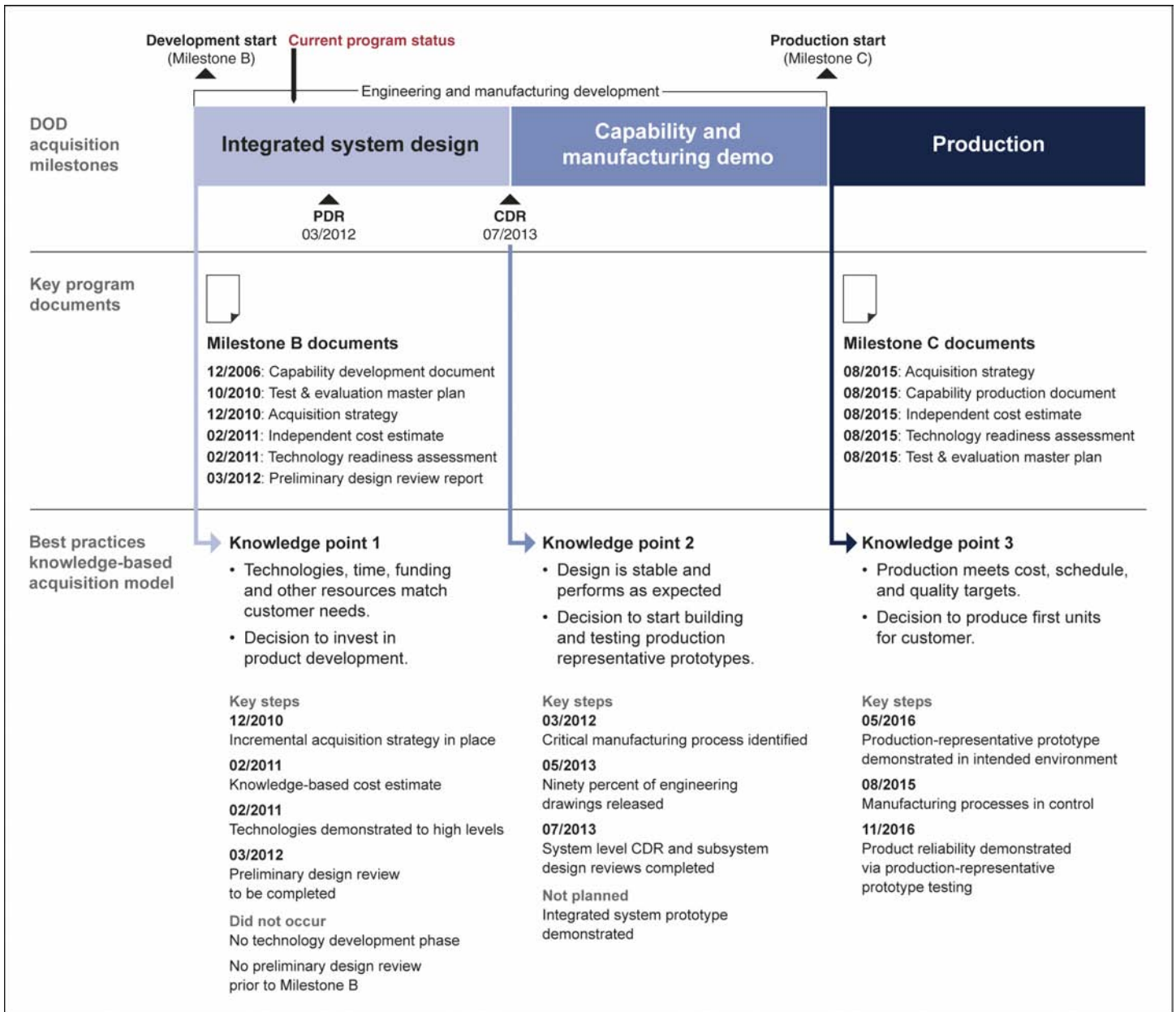
<sup>19</sup>Integrated Baseline Review is a formal review conducted by the government program manager and technical staff, jointly with their contractor counterparts, following contract award to verify the technical content of the performance measurement baseline and the accuracy of the related resource (budgets) and schedules.

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Figure 4 depicts how the KC-46 program office is incorporating a best practices approach into its acquisition framework including the planned dates key events are scheduled and how the plan compares to GAO's knowledge-based process for development. As the program progresses, we will continue to assess its performance against acquisition best practices, using figure 4 as a template.



**Figure 4: KC-46 Planned Program Events Compared to GAO Best Practices**



Source: GAO presentation of Air Force data.

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## Program Did Not Have a Technology Development Phase and Waived Preliminary Design Review

Although the program is implementing many acquisition best practices, the program office did not conduct a technology development phase and instead proceeded directly to the engineering and manufacturing development phase. As discussed earlier, the program's three critical technologies were assessed as approaching maturity and meeting internal defense policy, but below the fully mature level in best practices. Our prior work consistently shows that programs going directly into development before fully maturing all critical technologies typically incur additional costs and take longer to complete. Additionally, DOD granted a waiver to the program from having to conduct a preliminary design review—a major step initially solidifying the aircraft's design—before starting system development. Instead, the program office has plans to conduct this review over a year after the start of development in March 2012 due to their assessment that integrating KC-46 unique military requirements onto a commercial aircraft is low to moderate risk. We have previously reported that holding a preliminary design review prior to development start can help ensure requirements are well-defined and feasible.<sup>20</sup> Nonetheless, the program did complete its system functional review in November 2011 and made no significant changes to program requirements. The program plans to demonstrate the system's design is stable and have 90 percent of KC-46 design drawings released by its projected July 2013 critical design review.

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## KC-46 Program is Incorporating Recent Acquisition Reform Legislation in Development

The Weapon Systems Acquisition Reform Act of 2009 (Reform Act)<sup>21</sup> requires DOD and the military services to place more emphasis on activities that should occur early in weapon systems development, including those related to systems engineering and developmental testing, to establish a solid program foundation when development begins. To comply with this legislation, the KC-46 program office is tracking key program events to the relevant section of the Reform Act. For example, the program office held an independent Technology Readiness Assessment (TRA) which reviewed 36 technologies, identified 3 as critical technologies, and assessed the maturity of all the

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<sup>20</sup>GAO, *Defense Acquisitions: Application of Lessons Learned and Best Practices in the Presidential Helicopter Program*, [GAO-11-380R](#) (Washington, D.C.: Mar. 25, 2011).

<sup>21</sup>Pub. L. No. 111-23.

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technologies.<sup>22</sup> In addition, the KC-46 program is using a time-defined acquisition strategy based on cost, schedule, and performance trades with a 78-month development cycle and is using an incremental strategy to replace the tanker fleet of KC-135s and KC-10s with the KC-46, and potentially the KC-Y and KC-Z programs. The Reform Act requires DOD to periodically review and assess the technology maturity and the risk of integrating critical technologies of weapon system programs, and requires officials responsible for acquisition, budget, and cost estimating functions to develop estimates and raise cost and schedule matters before performance objectives are established. Appendix III provides a comparison of the Reform Act requirements and program compliance.

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## Key Program Documentation Complies with DOD Policy

The KC-46 key program documentation completed prior to development start compares favorably with requirements in DOD policy for defining program capabilities and system requirements as outlined in the Joint Capabilities Integration and Development System (JCIDS)<sup>23</sup> manual. Appendix IV provides a detailed assessment of this compliance, but some examples include:

- The Initial Capabilities Document (ICD)<sup>24</sup> identifies capability gaps with the KC-135 fleet in the areas of night-time refueling systems, defensive systems, and communication capabilities. It defines what capabilities will be required in a new tanker aircraft.
- The KC-46 Capability Development Document (CDD)<sup>25</sup> describes how capability gaps identified in the ICD will be addressed by developing

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<sup>22</sup>A TRA is a formal, systematic, metrics-based process and accompanying report that assesses the maturity of technologies called Critical Technology Elements (CTEs) to be used in systems. CTEs can be hardware or software. DOD Technology Readiness Assessment Deskbook, section 1.1.

<sup>23</sup>JCIDS plays a key role in identifying the capabilities required by the warfighters to support the National Defense Strategy, the National Military Strategy, and the National Strategy for Homeland Defense. Successful delivery of those capabilities relies on the JCIDS process working in concert with other joint and DOD decision processes.

<sup>24</sup>The ICD defines a capability gap or other deficiency in terms of the functional area, the relevant range of military operations, and the timeframe. It also describes the evaluation of Doctrine, Organization, Training, Materiel, Leadership and education, Personnel, and Facilities (DOTMLPF) approaches.

<sup>25</sup>The CDD is a document that captures the information necessary to develop a proposed program(s), normally using an evolutionary acquisition strategy. It outlines an affordable increment of militarily useful, logistically supportable, and technically mature capability.

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KPPs, system characteristics that are considered to be critical to delivering a military capability, and Key System Attributes, lower priority characteristics which are nevertheless essential for effective military capability. The KC-46 CDD defines how each KPP will be addressed in areas including aerial refueling and threats, and how classified information is to be collected and stored.

- The KC-46 System Requirements Document (SRD)<sup>26</sup> discusses the scope of program requirements and presents the technical performance required for the replacement tanker. The SRD also defines how some minimum performance requirements are mandatory, and how other requirements identified as non-mandatory are part of the Air Force's trade space.<sup>27</sup> System requirements discussed in the KC-46 SRD included aerial refueling, airlift, information management, and survivability.

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## Conclusions

The KC-46 acquisition is a high-priority/high-profile program essential to ensuring continued delivery of aerial refueling capabilities to future U.S. military operations. Its fixed-price incentive (firm target) development contract is designed to limit the government's liability for increased costs. Because senior defense officials are encouraging acquisition programs across the department to adopt similar arrangements, when appropriate, it will be both illustrative for the policy and important for future programs to monitor the KC-46's progress and its degree of success. Some would argue that a degree of program success has already been demonstrated because the government's cost liability, assuming no system requirements changes, has been capped and the contractor is still required to provide full performance of the contract. However, even with these safeguards, it is important to note that 1 year into development, Air Force and contractor development cost estimates exceed the development contract amount and significant schedule risks have been identified. Although the KC-46 program is still in its early stages, similar cost and schedule pressures have dogged many past and present

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<sup>26</sup>A SRD establishes the basis for an acquisition program functional baseline. It documents acquisition requirements translated from a warfighter Capability Based Requirements document into an acquisition format used as a baseline for a system or subsystem specification typically prepared by a contractor.

<sup>27</sup>Trade space can be defined as the set of program and system parameters, attributes, and characteristics required to satisfy performance standards. Decision makers define and refine the developing system by making tradeoffs with regard to cost, schedule, risk, and performance; all of which fall within the system's trade space.

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defense acquisition programs. With 5 years of development remaining on an aggressive schedule with substantial concurrency among development, test, and production activities, prudence and strong management attention is warranted. Should costs continue to increase, or schedule or performance measurement lag, there could be increased pressure to reopen or renegotiate aspects of the contract. This would probably not be advantageous to the Air Force.

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## Recommendations for Executive Action

As one of only a few major acquisition programs to award a fixed-price incentive (firm target) development contract in recent years, evaluating performance and identifying lessons learned will be very illustrative and important to inform decision-makers and help guide and improve future defense acquisition programs. Therefore, we recommend that the Under Secretary of Defense for Acquisition, Technology and Logistics closely monitor the cost, schedule, and performance outcomes of the KC-46 program to identify positive or negative lessons learned.

To help ensure that progress toward achievement of the program's key performance parameters can be appropriately measured as development progresses toward production, we recommend the KC-46 program manager, as soon as possible, fully implement sound metrics for each parameter.

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## Agency Comments

DOD provided us with written comments on a draft of this report which are reprinted in appendix V. DOD concurred with our two recommendations. In written comments, DOD provided additional information on its plans to manage schedule risk and mature technologies. We also incorporated technical comments as appropriate.

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We are sending copies of this report to appropriate congressional committees; the Secretary of Defense; the Secretary of the Air Force; and the Director of the Office of Management and Budget. The report also is available at no charge on the GAO Web site at <http://www.gao.gov>.

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If you or your staff has any questions concerning this report, please contact me at (202) 512-4841 or [sullivanm@gao.gov](mailto:sullivanm@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff contributing to this report are listed in appendix VI.

A handwritten signature in black ink, appearing to read "Michael J. Sullivan". The signature is fluid and cursive, with a long horizontal stroke at the end.

Michael J. Sullivan  
Director  
Acquisition and Sourcing Management

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*List of Committees*

The Honorable Carl Levin  
Chairman  
The Honorable John McCain  
Ranking Member  
Committee on Armed Services  
United States Senate

The Honorable Daniel K. Inouye  
Chairman  
The Honorable Thad Cochran  
Ranking Member  
Subcommittee on Defense  
Committee on Appropriations  
United States Senate

The Honorable Howard P. McKeon  
Chairman  
The Honorable Adam Smith  
Ranking Member  
Committee on Armed Services  
House of Representatives

The Honorable C.W. Bill Young  
Chairman  
The Honorable Norman D. Dicks  
Ranking Member  
Subcommittee on Defense  
Committee on Appropriations  
House of Representatives

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# Appendix I: Scope and Methodology

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We interviewed officials from the KC-46 program, Air Force, and Office of the Secretary of Defense (OSD) to obtain their views on progress, ongoing concerns and actions taken to address them, and future plans to complete KC-46 development. We also reviewed key program documentation for compliance with current Department of Defense (DOD) policy, acquisition reform legislation, and GAO best practices for weapon system development.

To determine the program's acquisition strategy, including its contracting approach, we reviewed briefings by program and contractor officials, budget documents, the Acquisition Program Baseline (APB), the Selected Acquisition Report (SAR), monthly activity reports, performance indicators, risk assessments and other data. We identified changes in cost and schedule, and obtained officials' reasons for these changes, and reviewed the KC-46 acquisition strategy in order to identify the program's Key Performance Parameters and what measures the program office has taken to develop metrics and track contractor performance in these areas. We also examined the acquisition strategy for aircraft development and production, but we could not assess the contractor's manufacturing processes because the program is only one year into development and it is too early for this assessment. To assess the development contract structure, we reviewed and analyzed the factors used to determine the contract geometry: target cost, target profit, ceiling amount, and profit adjustment formula for the current contract and also compared this against current DOD policy for contract geometry, the Federal Acquisition Regulation, and the Fiscal Year 2007 National Defense Authorization Act. To determine program costs, we reviewed the OSD Cost Assessment and Program Evaluation Independent Cost Estimate and the Air Force's Service Cost Position, the estimate which is used by the KC-46 program to plan its expected costs. We reviewed each estimate's underlying assumptions including how the estimate was developed and the confidence level used. We also requested information from the program office on whether the SCP cost estimate followed guidelines in GAO's 2009 Cost Estimating Guide.

In order to evaluate the major schedule and technical risks faced by the program, we reviewed the KC-46 Integrated Master Schedule and compared it to the program's APB and SAR in order to identify potential concurrency in the program's design reviews, flight testing, and low rate production. We also asked program officials how they are monitoring planned schedule events. To identify potential program risks, we reviewed the program's Technology Readiness Assessment which identifies critical technology elements and the plan for maturation of these



technologies. During interviews with program officials we discussed what actions are currently being taken in the areas of earned value management and contractor performance in order to identify problems early in the engineering and manufacturing development phase and ways they planned to mitigate these risks.

To assess the extent the program is complying with acquisition policy, legislation, and best practices, we also compared key program documentation and execution with current DOD policy, GAO best practices, and recent acquisition reform legislation to determine areas of compliance and areas for further review as the program continues forward. We compared the KC-46 Initial Capabilities Document, the Capability Development Document, and the System Requirements Document against DOD policy and guidance. We also reviewed program office documentation pertaining to implementing relevant portions of the Weapon Systems Acquisition Reform Act of 2009 and compared program actions back to the legislation to determine whether requirements in the Reform Act are being incorporated into program decisions. We also examined and compared program office schedule documentation, such as the Integrated Baseline Review against GAO's best practices acquisition framework to identify areas in which the program office is utilizing a knowledge-based approach in KC-46 development.

In performing our work, we obtained information or interviewed officials from Air Mobility Command and the KC-46 program office, Wright-Patterson Air Force Base, OH; Defense Contract Management Agency, Seattle, WA; and Federal Aviation Administration, Wichita, KS. We also met with and obtained information from the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, in Washington, D.C.

We conducted this performance audit from September 2011 to March 2012 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.

# Appendix II: KC-135 Fleet Capabilities Compared to KC-46 Planned Capabilities for Aerial Refueling

Capability area	<p>KC-135 (414 Aircraft)</p>	<p>KC-46 (179 Aircraft)</p>
<b>Boom, hose and drogue refueling</b>	<ul style="list-style-type: none"> <li>Permanent hose and drogue capability does not exist</li> <li>200,000 lbs total fuel offload</li> <li>Cannot utilize boom and hose and drogue on same flight</li> <li>1,176 gallons per minute offload rate</li> <li>Hydraulic operated</li> <li>20 aircraft are configured to accept wing pods</li> </ul>	<ul style="list-style-type: none"> <li>Permanent centerline hose and drogue refueling system</li> <li>207,672 lbs total fuel offload</li> <li>Can utilize boom and hose and drogue on same flight</li> <li>1,200 gallons per minute offload rate</li> <li>Fly-by-wire (computer assisted) using KC-10 modernized design</li> <li>All aircraft will be configured to accept wing pods; 46 wing pod sets will be procured</li> </ul>
<b>Cargo/ passenger/ medical patients</b>	<ul style="list-style-type: none"> <li>Cargo Capacity 83,000 lbs</li> <li>Maximum 6 cargo pallets</li> <li>Maximum 53 passengers</li> <li>Maximum 44 medical patients</li> </ul>	<ul style="list-style-type: none"> <li>Cargo Capacity 65,000 lbs</li> <li>Maximum 18 cargo pallets</li> <li>Maximum 114 passengers</li> <li>Maximum 58 medical patients</li> </ul>
<b>Communications, navigation, and surveillance/air traffic management</b>	<ul style="list-style-type: none"> <li>Some configurations require significant modifications to meet future Federal Aviation Administration (FAA) and International Civil Aviation Organization certification</li> </ul>	<ul style="list-style-type: none"> <li>The KC-46 will have necessary navigation and communication equipment for worldwide operations plus the capability to operate during times of spectrum interference of communications, navigation, and radar</li> </ul>
<b>Secure airborne communications</b>	<ul style="list-style-type: none"> <li>Current tankers do not have required connectivity to command and control (C2) agencies and have very limited Command, Control, Communications, and Computers (C4) connectivity to other combat, combat support, and mobility aircraft</li> <li>Very limited secure airborne communications capability exists</li> </ul>	<ul style="list-style-type: none"> <li>Increased threat data and secured data link for classified information</li> <li>787 model based digital cockpit with advanced avionics and air refueling data displays</li> </ul>
<b>Defensive protection</b>	<ul style="list-style-type: none"> <li>The current fleet lacks sufficient defensive protection capabilities</li> </ul>	<ul style="list-style-type: none"> <li>Threat detection and infrared defeating systems</li> <li>Cockpit armor</li> <li>Fuel tank ballistic protection</li> <li>Electromagnetic pulse hardening for nuclear protection</li> <li>Ability to conduct mission in chemical and biological threat environment</li> </ul>
<b>Multipoint refueling</b>	<ul style="list-style-type: none"> <li>Limited to 20 tankers that have the capability to attach wing-mounted refueling pods and conduct multipoint refueling of two aircraft</li> </ul>	<ul style="list-style-type: none"> <li>All tankers will have the capability to attach wing pods and conduct multipoint refueling of two aircraft, but only 46 sets of wing-mounted pods will be procured</li> </ul>
<b>Night-time refueling</b>	<ul style="list-style-type: none"> <li>Lack of a standard night vision imaging system (NVIS) for tanker cockpits and boom operator positions</li> <li>Limited exterior lighting is not currently NVIS compatible, which prohibits air refueling in tactical conditions</li> </ul>	<ul style="list-style-type: none"> <li>NVIS compatible flight deck, passenger and cargo locations</li> <li>External lighting allows for refueling in tactical conditions</li> </ul>
<b>Receiver capabilities (tanker to tanker refueling)</b>	<ul style="list-style-type: none"> <li>8 KC-135s have air refueling receptacles that have the capability to onload fuel while airborne</li> <li>730 gallons per minute onload</li> </ul>	<ul style="list-style-type: none"> <li>All 179 KC-46 aircraft to have air refueling receptacles</li> <li>1,200 gallons per minute onload</li> </ul>
<b>Situational awareness</b>	<ul style="list-style-type: none"> <li>Periscope mirror system</li> <li>49 degree field-of-view</li> </ul>	<ul style="list-style-type: none"> <li>High resolution cameras</li> <li>185 degree field-of-view</li> </ul>

Source: GAO presentation of Air Force information; © Boeing Company (photos).

# Appendix III: DOD and KC-46 Program Office Implementation of Applicable Sections of the 2009 WSARA

WSARA Section	Requirement	DOD and KC-46 Program Office Implementation
<b>Title I: Acquisition Organization</b>		
Section 104: Assessment of Technological Maturity of Critical Technologies of Major Defense Acquisition Programs by the Director of Defense Research and Engineering	Requires Director, Defense Research & Engineering (DDR&E) to periodically review and assess the technology maturity and integration risk of critical technologies of Major Defense Acquisition Programs (MDAP). Requires DDR&E to develop knowledge-based standards to measure technology maturity and integration risk.	<ul style="list-style-type: none"> <li>An independent Technology Readiness Assessment (TRA), approved by DDR&amp;E</li> <li>The assessment reviewed 36 technologies, identified 3 critical technologies elements, and assessed them as mostly mature</li> </ul>
<b>Title II: Acquisition Policy</b>		
Section 201: Consideration of Trade-Offs among Cost, Schedule & Performance Objectives in DOD Acquisition Programs	The Secretary of Defense shall ensure consideration of trade-offs among cost, schedule, and performance objectives as part of the process for developing requirements for DOD acquisition programs. DOD officials responsible for acquisition, budget, and cost estimating functions shall provide appropriate opportunity to develop estimates and raise cost and schedule matters before performance objectives are established. The process for developing requirements is structured to enable incremental, evolutionary, or spiral acquisition approaches.	<ul style="list-style-type: none"> <li>KC-46 System Requirements Document reduced requirements to 372 mandatory and 93 non-mandatory that represented capability trade space</li> <li>Time-defined acquisition strategy based on cost, schedule, performance trades (78 month development cycle)</li> <li>Employing incremental KC-46, KC-Y, and KC-Z strategy</li> </ul>
Section 202: Acquisition Strategies to Ensure Competition Throughout the Lifecycle of Major Defense Acquisition Programs	Requires DOD to implement recommendations to ensure competition at the MDAP contract and subcontract level. Highlights several measures to ensure competition, where cost-effective.	<ul style="list-style-type: none"> <li>Contractor must support design, certification, approval and installation of future third party contractor modifications at best commercially available terms and conditions</li> <li>Employing incremental KC-46, KC-Y and KC-Z strategy</li> </ul>
Section 203: Prototyping Requirements for Major Defense Acquisition Programs	Requires the acquisition strategy for each MDAP provide for competitive prototypes before Milestone B approval, unless the milestone decision authority (MDA) for that MDAP waives such requirement. Allows the MDA to waive the requirement only on the basis that: (1) the cost of producing competitive prototypes exceeds the expected life-cycle benefits of producing the prototypes; or (2) but for such waiver, DOD would be unable to meet critical national security objectives.	<ul style="list-style-type: none"> <li>Waiver from competitive prototype was not required for KC-46 because the program entered the acquisition system directly at MS B with no prior Technology Development Phase</li> </ul>
<b>Title III: Additional Acquisition Provisions</b>		
Section 302: Earned Value Management	Modifies the 2009 National Defense Authorization Act, Section 887, requires report to Congress on implementation of Earned Valued Management (EVM) in DOD.	<ul style="list-style-type: none"> <li>KC-46 has successfully implemented all EVM and Integrated Baseline Review (IBR) requirements according to statute and regulation</li> </ul>

**Appendix III: DOD and KC-46 Program Office  
Implementation of Applicable Sections of the  
2009 WSARA**

<b>WSARA Section</b>	<b>Requirement</b>	<b>DOD and KC-46 Program Office Implementation</b>
Section 304: Comptroller General of the United States Reports on Costs and Financial Information Regarding Major Defense Acquisition Programs	Requires reports on growth in operating and support (O&S) costs and requires review of weaknesses in operations affecting the reliability of financial information for MDAPs.	<ul style="list-style-type: none"> <li>KC-46 program measuring and reporting on O&amp;S costs</li> </ul>

Source: GAO presentation of 2009 Weapon System Acquisition Reform Act (WSARA) legislation and KC-46 Program Office information provided to show compliance with WSARA.

# Appendix IV: KC-46 Program Compliance with Key Requirements Documents

Requirements Document	Specific Requirement	Program Compliance
Initial Capabilities Document	• Description of Concept of Operations	• Aerial refueling aircraft will be rapidly deployable, employable, and sustainable throughout global battlespace and environments
	• Capability Gap	• Continued successful accomplishment of the crucial aerial refueling mission is at risk due to increasing demands (already exceeding capability and decreasing availability) as a result of aircraft aging
	• Operational Environment Threat	• Mission requirements dictate aerial refueling aircraft must be capable of operating from worldwide locations day and night, under most operational atmospheric conditions and contain appropriate command, control, communications, and intelligence interfaces and capability for inter-aircraft situational awareness
Capability Development Document	• Capability Discussion	• Provide worldwide, day/night, adverse weather aerial refueling on the same sortie to receiver capable US, allied, and coalition aircraft
	• Concept of Operations Summary	• Aerial refueling is integral to all Air Force core competencies and is used throughout the full spectrum of operations from combat to humanitarian support, including strategic attack, counterair, special operations, counterland, countersea, combat search and rescue, and airlift mission areas
	• Threat Summary	• Tanker aircraft must be able to operate in chemical, biological, and radiological environments as potential adversaries continue to enhance these capabilities
System Requirements Document	• Scope	• Presents the technical performance required for the replacement tanker aircraft
	• Purpose	• Tanker and Boom Aerial Refueling • Computer Resources • FAA Certification and Air Worthiness
	• Description	• Verification Factors/Methods • Testing and Analysis • Inspection

Source: GAO presentation of DOD and Air Force information.

# Appendix V: Comment from the Department of Defense



**DEPARTMENT OF THE AIR FORCE**  
HEADQUARTERS AERONAUTICAL SYSTEMS CENTER (AFMC)  
WRIGHT-PATTERSON AIR FORCE BASE OHIO

16 March 2012

ASC/WK  
2590 Loop Road West  
Wright-Patterson AFB OH 45433-7142

Michael J. Sullivan  
Director, Acquisition and Sourcing Management  
United States Government Accountability Office  
441 G St. NW  
Washington DC 20548

Dear Mr Sullivan

This is the Department of Defense (DoD) response to the General Accountability Office (GAO) draft report, GAO-12-366, "KC-46 Tanker Aircraft: Acquisition Plans Have Good Features But Contain Schedule Risk," dated February 16, 2012 (GAO CODE 121016).

The DoD is committed to effectively and efficiently executing the KC-46 program to the standard expected of us from the taxpayer, and in a way that holds Boeing accountable to their cost, schedule and performance commitments made during the source selection. The DoD is also committed to proactively and transparently supporting GAO's assessment process to provide Congress the needed program insight to fulfill their oversight role, and appreciates the opportunity to provide comments to this report.

The GAO report generally provided a fair and balanced assessment of the KC-46 program; however, there are a few areas where the Air Force would like to clarify or provide additional context to the report language.

- *The KC-46 program has some concurrency between development, testing and production, but nowhere near as much as most other major aircraft acquisition programs.* The KC-46 Directorate has assessed the schedule as having moderate risk. The Air Force clearly recognizes schedule as the top risk on the KC-46 program, as evaluated during source selection and the post-contract award Integrated Baseline Review. However, The Air Force believes the GAO assessment that the KC-46 program has "significant concurrency" overstates the actual level and impact of schedule concurrency between development, testing and production activity.

The KC-46 program will have completed approximately 60 percent of FAA certification and military developmental flight testing prior to a Milestone C decision and prior to entering into any concurrency with production, which is significantly more testing than most other major aircraft acquisition programs at this point in a program. This early FAA certification and military developmental testing starts with the First Flight of the baseline provisioned 767-2C aircraft in June 2014—for which the GAO's schedule graphic on page 12 does not give due credit—and continues with the First Flight of the militarized KC-46 tanker in January 2015, leading up to a Milestone C decision in August 2015.

The KC-46 program is being managed in an event-based manner; conduct of Milestone C and the award of low rate initial production are not driven by a contractually required date and will not be approved until Boeing demonstrates the knowledge and readiness required for low rate initial production. The Air Force will ensure adequate flight testing is completed prior to Milestone C. The Air Force will not allow risk to “travel downstream” where it can manifest into the cost and schedule impacts normally found in concurrency between testing and production.

The KC-46 program has a key contract provision that requires Boeing to incorporate fixes to all deficiencies found during testing into all future production aircraft, as well as into all production aircraft that have already been delivered, at no additional cost to the Government. The Air Force made this a contract requirement to mitigate any cost risk posed by concurrency between testing and production.

Boeing incorporated five months of schedule management reserve into their plans. Boeing’s baseline schedule expects to deliver the first 18 KC-46 aircraft five months earlier than the contractual date of August 2017. This management reserve in the schedule will be used if the test program cannot achieve its planned fly-rates, to correct deficiencies, or to re-fly test points. Boeing included this management reserve, in part, to mitigate risk to the schedule inherent in the concurrency between development, testing and production.

The Air Force is laser focused on Boeing’s schedule and holding them accountable to their contract commitment to deliver the first 18 aircraft to our warfighters by August 2017. Boeing has made every major milestone on schedule in the program thus far one year into contract execution. The Air Force has established a contract framework that provides Boeing extraordinary financial motivation and incentive to perform and delivery on time. If Boeing does not perform and deliver on time, the Government will hold Boeing accountable by seeking appropriate consideration.

- *All technologies used on the KC-46 program are at a Technology Readiness Level (TRL) 6 or higher in compliance with statutory requirements.* The Air Force believes the GAO report accurately captures this point; however, the Air Force would like to add that for the three critical technology elements on the program, the contract required Boeing to develop for Government approval—90 days after contract award—a technology maturation plan to advance the technologies to TRL 7 by Milestone C and TRL 9 by the Final Physical Configuration Audit (FPCA). Boeing is also contractually required to submit an update to these maturation plans for Government review prior to the Critical Design Review, Milestone C and the FPCA. The Air Force required these maturation plans in the contract to provide robust and sustained Government insight into the progress of each critical technology element during the development phase of the program.

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Appendix V: Comment from the Department of  
Defense

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Again, thank you for the opportunity to review this report. If you have any questions, please contact Lt Col Joe Wimmer, (571) 256-0509, [Joseph.Wimmer@Pentagon.af.mil](mailto:Joseph.Wimmer@Pentagon.af.mil), the Air Force's Primary Action Officer, or my point of contact Maj Jason Voorheis, (937) 656-9318, [Jason.Voorhies@wpafb.af.mil](mailto:Jason.Voorhies@wpafb.af.mil).

Sincerely,



CHRISTOPHER C. BOGDAN, Maj Gen, USAF  
KC-46 AFPEO and Program Director

Attachment:  
Department of Defense Comments to the  
GAO Recommendations



**GAO DRAFT REPORT DATED FEBRUARY 16, 2012  
GAO-12-366 (GAO CODE 121016)**

**“KC-46 TANKER AIRCRAFT: ACQUISITION PLANS HAVE GOOD FEATURES BUT  
CONTAIN SCHEDULE RISK”**

**DEPARTMENT OF DEFENSE COMMENTS  
TO THE GAO RECOMMENDATIONS**

**RECOMMENDATION 1:** As one of only a few major acquisition programs to award a fixed-price incentive (firm target) development contract in recent years, evaluating performance and identifying lessons learned will be very illustrative and important to inform decision-makers and help guide and improve future defense acquisition programs. Therefore, GAO recommends that the Secretary of Defense direct the Under Secretary of Defense for Acquisition, Technology and Logistics to closely monitor the cost, schedule, and performance outcomes of the KC-46 program to identify positive or negative lessons learned.

**DoD RESPONSE:** The DoD fully concurs with this recommendation and plans to closely monitor the cost, schedule and performance outcomes of the KC-46 program to identify positive or negative lessons learned. The Air Force has already started this process formally with the capture of detailed lessons learned from the KC-46 source selection, and will continue to do so as the program progresses through development.

**RECOMMENDATION 2:** To help ensure that progress toward achievement of the program's key performance parameters can be appropriately measured as development progresses toward production, GAO recommends that the Secretary of Defense direct the KC-46 program manager, as soon as possible, to establish sound metrics for each parameter.

**DoD RESPONSE:** The DoD fully concurs with this recommendation to establish sound metrics for each parameter. The KC-46 Directorate has now fully implemented a robust three-tiered approach to capture these metrics for each of the program's nine Key Performance Parameters (KPP) as well as each of the program's five Key System Attributes (KSA). Tier 1 is a top-level roll-up of each KPP's and KSA's status, and is depicted with a low, medium or high risk stoplight assessment. Tier 2 supports the Tier 1 assessment, and represents a mapping from each of the nine KPPs and five KSAs to the 114 associated contractual KC-46 System Specification requirements necessary to achieve each respective KPP and KSA. Each of these 114 KC-46 System Specification requirements is tracked by Government and Boeing subject matter experts, and is depicted with a low, medium or high risk stoplight assessment. Similarly, Tier 3 supports the Tier 1 and Tier 2 assessments, and establishes the lowest level Technical Performance Measure (TPM) that objectively tracks progress toward achieving each KPP and KSA. The Tier 3 measures are designated as either

“traditional” or “binary” TPMs. The “traditional” TPMs are objectively quantifiable and are generated by Boeing to status technical progress. Traditional TPMs currently support the KPPs and KSAs associated with Fuel Usage Rate, Fuel Offload, Reliability & Maintainability and Operational Availability. The requirements for all KPPs and KSAs do not lend themselves to quantifiable metrics and therefore binary TPMs were generated to track the status towards achieving the specified capabilities. These binary TPMs measure design progress by assessing the adequacy of requirements allocation as well as the timeliness of key development, integration and test events. In summary, a process is now in place to measure and status all KPPs and KSAs on a monthly basis.

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# Appendix VI: GAO Contacts and Acknowledgments

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## GAO Contact

Michael Sullivan (202) 512-4841 or [sullivanm@gao.gov](mailto:sullivanm@gao.gov)

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## Acknowledgments

In addition to the contact name above, the following staff members made key contributions to this report: Bruce Fairbairn, Assistant Director; Keith Hudson; John Krump; Mary Jo Lewnard; Don Springman; Roxanna Sun; and Robert Swierczek.

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