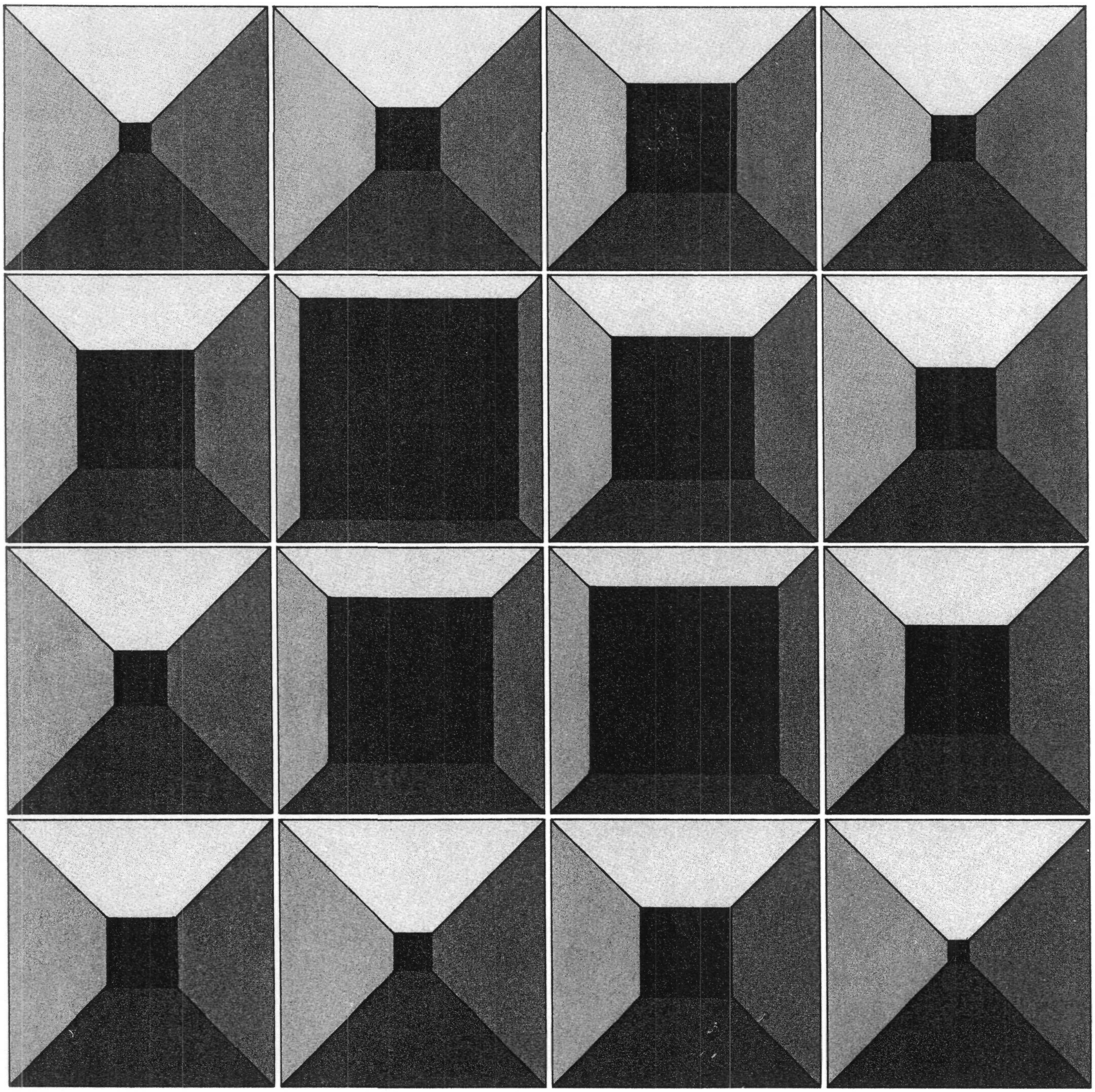
Aerial Tanker Force Modernization

A CBO Study
March 1982

Congress of the United States
Congressional Budget Office



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PREFACE

The Administration is proceeding with plans to expand and update the Air Force's fleet of tanker aircraft. By providing airborne refueling, tankers serve both to extend the flying ranges of bombers for strategic nuclear missions and also to assist other military aircraft in conventional non-nuclear contingencies. Thus, the extent of future need for tanker resources will depend not only on the number and type of bombers fielded over the next decade, but also on the demand for support of conventional non-nuclear missions. Requested by the Senate Committee on Armed Services, this study examines likely tanker needs over the next dozen years, especially in light of bomber force modernization plans; it also examines alternative approaches to meeting that demand. In accordance with CBO's mandate to provide objective and nonpartisan analysis, this paper offers no recommendations.

The study was prepared by John J. Hamre and David S. Neill, with special assistance from Bonita Dombey, under the supervision of Robert F. Hale of CBO's National Security and International Affairs Division. The computer methodology was developed by David Neill in cooperation with Dr. Bart McGuire and the University of California's Graduate School of Public Policy at Berkeley. Helpful criticism was given by Alfred B. Fitt, Ronald P. Kelly, Bart McGuire, Rich Davison, and Bill Myers of CBO's Budget Analysis Division; Bill Myers also assisted with the cost estimates. (The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.) The authors gratefully acknowledge the contributions of Johanna Zacharias, who edited the paper, and Janet Stafford, who prepared the manuscript for publication.

Alice M. Rivlin
Director

March 1982

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SUMMARY

Last October, the Reagan Administration announced a plan to update U.S. strategic nuclear forces. A centerpiece of that program was a commitment to build two new strategic bombers over the next decade. The first, a modified form of the B-1 bomber (which had been cancelled by President Carter in 1977) would be fielded in 1986. The second, a new advanced technology bomber (ATB) incorporating "stealth" technologies, would be deployed in the early 1990s. The current fleet of B-52s now being converted to carry cruise missiles will eventually be retired or retained as standoff cruise missile carriers as the new bombers enter service.

Much public debate has focused on the bombers. As important as the bombers themselves, however, is the large fleet of tanker aircraft used to refuel bombers in flight. Bombers could not execute their missions without using tankers to extend their ranges. The bomber modernization program, and especially the plans to retire a major portion of B-52s, have tremendous implications for current tanker resources.

Tankers also now figure prominently in conventional nonnuclear war plans, and they could prove indispensible, for instance, in projecting the Rapid Deployment Force (RDF) to distant theaters of operation. The need for substantial tanker capacity emerged especially clearly during the Arab-Israeli war in 1973, when U.S. airlift missions in support of Israel were nearly halted for the lack of mid-course refueling.

These two sets of developments--planned bomber development and the need not to rely on ground refueling--have led to efforts to expand U.S. tanker resources.

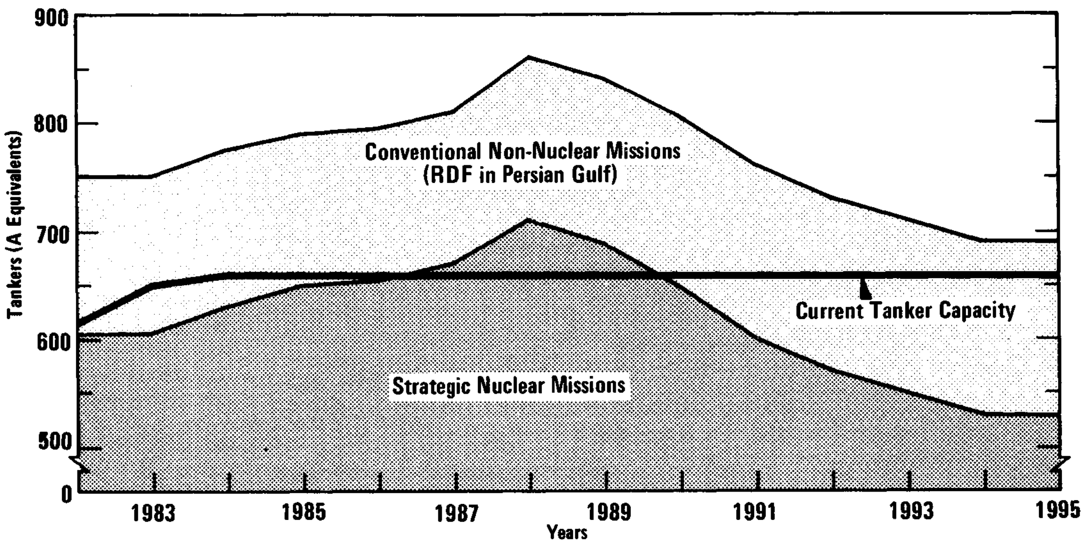
ESTIMATED FUTURE TANKER NEEDS

Through the 1980s, according to the Congressional Budget Office's analysis, tanker demand will substantially exceed current capacity, reaching a peak in the late 1980s, if no effort is made to increase tanker resources. In the longer term, however, after B-52 aircraft are retired from service and new bombers are fielded, tanker demand will not substantially exceed present

capacity, obviating the need for further tanker force expansion. (These trends are displayed in Summary Figure 1. This study estimates the number of tankers needed to support both strategic nuclear forces and conventional non-nuclear forces; requirements are expressed in terms of existing KC-135A tanker aircraft or their equivalents. The period studied by CBO extends from the present through fiscal year 1994.)

Summary Figure 1.

Projected U.S. Tanker Aircraft Demand for Strategic Nuclear and Conventional Non-Nuclear Missions, 1982-1995



SOURCE: Congressional Budget Office.

In recent years, the Congress has promoted the expansion of tanker resources. It must now confront the apparently contradictory issues of near-term shortages and potential longer-term excesses, since current Administration tanker initiatives will boost capacity well above projected demand. This study examines three alternative means the Congress might consider for increasing the Air Force's tanker fleet resources:

- o Installing new generation CFM-56 engines on existing KC-135 tanker aircraft (predecessors of the Boeing 707);
- o Installing older generation, though refurbished, JT3D engines on the KC-135s. (Those engines would be salvaged from commercial transports being retired from service);
- o Continuing to procure the advanced KC-10 tanker (a modified form of the commercial DC-10 transport).

This analysis indicates that the KC-10, while the most costly alternative on a per airplane basis, is the least expensive way to expand tanker resources, as is shown in Summary Table 1. The next most cost-effective choice is the use of older generation JT3D engines on current KC-135 tankers. The least cost-effective option is the re-engining program using modern CFM-56 engines.

SUMMARY TABLE 1. INVESTMENT COSTS OF ADDITIONAL TANKER EQUIVALENTS (Based on average improvement of tanker alternatives)

Option	Average Improvement (percent)	In millions of 1983 dollars: Average Investment Cost	In millions of 1983 dollars: Investment Cost per Tanker Equivalent
KC-135R Aircraft with CFM-56 Engine	43	20.0 a/	46.5
KC-135E Aircraft with JT3D Engine	19	7.2 a/	37.9
KC-10 Aircraft	276	70.0 b/	25.4

SOURCE: Congressional Budget Office.

a/ Includes funds to update selected aircraft subsystems.

b/ Includes some $4 million to adapt aircraft for nuclear missions.

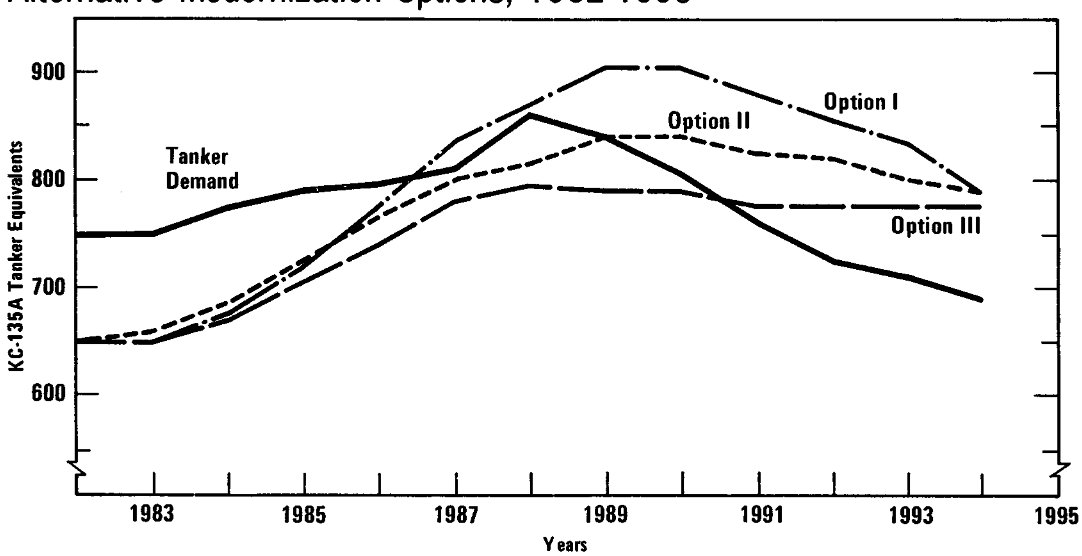
Equally important, this analysis indicates that effects of the alternatives vary in timing. These two factors--varying costs and timing--distinguish these three approaches.

THREE STRATEGIES FOR TANKER MODERNIZATION

Option I. The Administration Program

Over the next five years, the Administration intends to re-engine approximately 300 tankers with CFM-56 engines. To improve airlift capabilities, it also proposes to buy an additional 44 of the new KC-10s. Since these transports are particularly useful as tankers, they are evaluated here for their contribution to meeting aerial refueling needs. These two undertakings are estimated to cost a total of approximately $8.5 billion over the next five years. (Unless otherwise specified, costs are expressed in fiscal year 1983 dollars.) The Administration's program would fall short of tanker requirements until 1987. From that point on, the Administration's alternative would provide substantial excess capacity, especially after tanker demand has peaked and begun to decline in the late 1980s (see Summary Figure 2).

Summary Figure 2.
Projected U.S. Tanker Aircraft Demand and Alternative Modernization Options, 1982-1995



SOURCE: Congressional Budget Office.

Option II. Match Performance of the Administration Program But at Less Cost

Of the two engines with which current tankers could be fitted, the JT3D engine is less capable than the CFM-56, but it is more cost effective. In an effort to economize within Defense Department accounts, the Congress could choose to refit 185 KC-135 tankers with the older generation JT3D engines instead of the costlier CFM-56s; the savings could be substantial. Re-engining more than 185 aircraft would not be necessary, since the additional re-engined tankers would not become available much before 1989, when demand is expected to fall; and anticipated capacity should prove sufficient. The exact number and timing of these modifications reflect the likely availability of retiring commercial Boeing 707 transports. (The program outlined here is an expanded version of one explored by the Air Force last year but dropped because of budgetary constraints. The Congress directed DoD to pursue this option in 1982. The Air Force plans to re-engine 28 KC-135s with JT3D engines, though it does not intend to continue the program after fiscal year 1982.)

This alternative would provide the capabilities of Option I through 1986; after that date, however, capabilities would diverge markedly (see Summary Figure 2). By 1989, tanker demand is projected to fall below the point at which either program would meet demand.

Choosing this alternative would cost about $3.8 billion, or some $4.7 billion less than the Administration program over the next five years. The option would achieve only about 40 percent as much noise reduction as would re-engining with CFM-56 engines, which is one important distinction. In other respects, though, this option would achieve much of the improvement in fleet capability at dramatically less cost than the Administration proposal.

Option III. Limit Tanker Modernization to KC-10 Procurement

The CBO has found that the KC-10 is the most cost-effective tanker alternative. As noted above, the Administration intends to purchase 44 KC-10s over the next five years, primarily as a cargo transport. Since the aircraft was sought initially as a tanker and would be bought with those features intact, it is evaluated here as a tanker aircraft. The Congress could choose to limit tanker modernization to the Administration's plans to buy additional KC-10 transports. Summary Table 2 shows a modernization

SUMMARY TABLE 2. UNIT PURCHASES AND PROGRAM COSTS FOR ALTERNATIVE MODERNIZATION PROGRAMS

Cost Component	Through 1982	1983	1984	1985	1986	1987	Total
			Option I--The Administration Program				
Procure KC-10 Aircraft	18 a/	8	8	8	8	10	60
Refit KC-135 Aircraft with CFM-56 Engine	9	25	58	64	72	72	300
Cost (billions of 1983 dollars)		1.47	1.84	1.80	1.78	1.57	8.45
			Option II--Lower Cost Modernization				
Procure KC-10 Aircraft	18 a/	8	8	8	8	10	60
Refit KC-135 Aircraft with JT3D Engine	28	48	48	48	13		185
Cost (billions of 1983 dollars)		1.18	0.85	0.80	0.53	0.41	3.77
			Option III--Procure KC-10 Aircraft Only				
Procure KC-10 Aircraft	18 a/	12	12	12	6		60
Cost (billions of 1983 dollars)		1.13	0.76	0.65	0.27		2.81

SOURCE: Congressional Budget Office.

a/ Assumes the Congress endorses the Administration request for two KC-10s in the fiscal year 1982 supplemental appropriation.

program that would purchase those 44 KC-10 tankers, but at an accelerated pace, over the next four years.

This alternative would offer much of the performance of the previous two options but at dramatically less cost. The all-KC-10 alternative would meet between 85 and 95 percent of all requirements through 1989. Cancelling all further re-engining with either of these two engine choices would save nearly $5.7 billion over the next five years.

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CHAPTER I. A PERSPECTIVE ON THE TANKER AIRCRAFT PROGRAM

The U.S. Air Force maintains a large fleet of tanker aircraft that can refuel bombers and other military aircraft while airborne, thus extending their flying ranges and obviating the need for intermediate refueling bases. For several years, the Department of Defense (DoD) has sought to expand the capacity of the tanker fleet both by buying new advanced tankers and by improving the performance of existing aircraft. The justification for augmenting the tanker force depends not only on the number of aircraft in use that can be refueled while airborne, but also on fundamental decisions regarding the future of strategic bomber modernization plans. This study examines tanker modernization in light of the DoD's present and likely future demand for aerial refueling, specifically examining the effects of plans to modernize bomber aircraft. The paper offers answers to two questions:

- How much tanker capacity will be needed in the future?
- With different investment levels, what is the most effective mix of tanker alternatives for meeting anticipated demand?

EXPANDED REQUIREMENTS AND THE NEED FOR TANKER MODERNIZATION

The Air Force pioneered development of equipment and procedures by which one aircraft can transfer fuel to another while both are airborne. Tankers were conceived as a way to extend the flying range of bombers, permitting basing at secure rear bases or in the United States, rather than at vulnerable and expensive "forward staging areas." (These terms are explained in the Glossary at the end of this chapter.) The primary tanker--the KC-135A, which was the prototype of the commercial Boeing 707--is still in operation. The KC-135 tankers were introduced in 1957 and were intended to accompany the B-52 bombers then just entering service. Some 820 KC-135s were delivered, and some 640 are still dedicated to supporting B-52 and FB-111 bombers assigned to the Strategic Air Command (SAC). Despite the fact that a good many bombers have been retired over the last 20 years, SAC still needs large numbers of tankers. This is because the DoD's present war scenarios would require that SAC bombers fly for long distances at low altitudes in enemy air space. These two factors--long distances and low-altitude operations (which dramatically increase fuel consumption)--point to a need for ample tanker support for SAC bombers.

In recent years, the Air Force has sought to expand tanker resources to meet demands greater than can be served by the existing fleet. Three factors have been cited to justify this expansion. First, the number of aircraft capable of in-flight refueling has increased markedly. In the late 1950s, only SAC bombers could refuel in the air. Today, however, aerial refueling plans figure prominently in support of conventional non-nuclear operations as well as strategic nuclear war plans. All Air Force aircraft now being produced (except trainers) can be refueled in flight, and several important types of older aircraft are being modified to add that feature.

The second justification derives from recent experience. The United States' participation in the 1973 Arab-Israeli conflict consisted of the use of transport aircraft to deliver emergency cargo to Israel. Fearing reprisals, most countries between the United States and the Middle East refused permission for U.S. military transports to land for refueling. Though Portugal ultimately gave permission to use Lajes Field in the Azore Islands for refueling, the general reluctance of most countries demonstrated the possibility that future airlift operations in politically sensitive situations might require substantial numbers of tankers to provide airborne refueling. Tankers used for that purpose would not be immediately available to support strategic bombers, though some could be redirected for that purpose in a matter of hours.

Plans to update the aging B-52s underlie the third justification. At present, bombers would, in the event of war, attack enemy targets with short-range weapons, on so-called "penetration" missions. Tanker requirements will temporarily increase because of the decision to modify B-52 bombers to carry cruise missiles. Current modification plans proceed in two phases. Cruise missiles will initially be installed on pylons under the wings. In this first phase, B-52s, after launching all 12 cruise missiles mounted on the pylons, would continue into enemy territory to attack other targets with short-range weapons. 1/ This so-called

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1/ Short-range weapons consist of nuclear gravity bombs as well as Short Range Attack Missiles (SRAMs).

"shoot-and-penetrate" flight plan increases fuel and tanker requirements, since the weight of the cruise missiles displaces fuel in order to stay within aircraft gross weight limitations at takeoff, while the cruise missiles themselves add to air resistance ("drag") during flight. In the second phase, when cruise missiles are installed in the bomb bays of the bombers, tanker requirements will decline substantially, since B-52 bombers will "stand off" only and not have to fly over enemy territory.

The Administration recently announced plans to update the strategic bomber force by building both a modified version of the B-1 bomber to carry cruise missiles and short-range weapons, and by proceeding with the new advanced technology bomber (ATB) incorporating so-called "stealth" technologies, which limit its susceptibility to detection by Soviet air defense radars. B-52 bombers will be converted into carriers of cruise missiles and later retired, when both the B-1 and the ATB are fielded. The bomber program, as is shown below, dramatically increases tanker requirements over the next five years. Longer-term tanker demand, on the other hand, may not justify so expansive a tanker modernization program. In other words, there is only an interim period during which the need for such a program is clear.

CONTENDING APPROACHES TO EXPAND TANKER RESOURCES

The Air Force has available three possible programs that would increase tanker capacity. Two involve efforts to improve the performance of existing KC-135 tankers. The third involves procurement of new tanker aircraft--the KC-10. Each option is discussed below.

Replacing Engines on Existing KC-135 Tankers

Re-Engining with the CFM-56. During the past five years, the Air Force has developed a program to replace existing engines on the present KC-135A tanker with a new generation of turbofan engines called the CFM-56. 2/ The greater power of the engines

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2/ The re-engining program parallels commercial proposals to the airlines to replace old engines on Boeing 707s and DC-8s. Most airlines found that savings from re-engining their early model 707s were not sufficient to justify the initial increases the allowable takeoff weight and thereby the fuel payload, and the improved efficiency of the engines means they consume less of that payload for their own operation, thus leaving more fuel to be transferred to receiving aircraft. The re-engined KC-135 (designated the KC-135R) would also be substantially quieter and less affected by seasonal weather conditions than the existing KC-135A model. 3/ This program is the primary Administration alternative for meeting future tanker needs.

Re-Engining with Salvaged Commercial Engines. In 1981, the Air Force explored options to buy used Boeing 707s from several commercial airlines. The airlines are eager to sell the aircraft, because their engines will not meet more rigid noise and pollution standards that will be in force in 1985, effectively grounding the fleet. The Air Force intended to remove and refurbish the engines and related equipment on the 707s and install them on existing KC-135s. 4/ The salvaged and refurbished JT3D engines offer substantial improvement over existing KC-135 engines, though not so good as the CFM-56 noted above. Their principal asset is the speed with which they can be fielded and their low investment cost, estimated to be between 20 and 40 percent of the cost of re-engining with new generation CFM-56 engines. Last year, the Congress directed DoD to spend up to $85 million to develop this alternative. The Air Force initially

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investment in new engines. DC-8 aircraft, however, are being re-engined. General Electric and Snecma, a French firm, jointly produce the CFM-56.

3/ At present, the KC-135 cannot meet Federal Aviation Regulations on allowable noise and pollution emmission standards for commercial aircraft. Military aircraft are exempt from such regulations. However, Air Force Reserve units operating KC-135 tankers frequently are based near large metropolitan centers and have been the subject of local complaints. The Air Force Reserve has frequently testified in favor of re-engining, largely for the advantages it offers in avoiding local political pressure to restrict KC-135 operations.

4/ The refurbished engines would provide some 6,000 service hours of operation. At commercial airline tempo, that would be used up in less than three years. Military aircraft fly substantially fewer hours. At the current flying pace of 326 hours per year, the refurbished engines would last some 18 years.

objected, since the Congress instructed DoD to undertake JT3D re-engining with funds provided for CFM-56 re-engining. Air Force accounts were subsequently increased to permit funding of both programs. The Air Force has now made arrangements to re-engine 28 tankers with the JT3D engine in fiscal year 1982, though it plans no further use of this alternative.

Advanced Tanker/Cargo Aircraft

In the early 1970s, the Defense Department sought to expand its tanker fleet by taking advantage of the inherently greater efficiency of new generation wide-body commercial transports over the first generation jet aircraft like the KC-135. The Air Force selected McDonnell-Douglas' DC-10, designated for military use as the KC-10, as an advanced tanker. The improved range and payload of the KC-10 made it a particularly attractive prospect in the days after U.S. airlift operations in the Arab-Israeli war. In addition to its tanker functions, the KC-10 has substantial cargo capacity, and it can be used in conjunction with tanker operations. A KC-10 can not only ferry fighter planes to distant theaters; it can also transport initial issues of support equipment and personnel at the same time. Unlike previous tanker programs, the KC-10 was primarily justified for use in support of conventional general-purpose forces.

During the past year, decisions about the KC-10 program have undergone four complete reversals. The final defense budget of the Carter Administration terminated the program, though in March 1981, the Reagan Administration restored the original Air Force request for eight aircraft in fiscal year 1982. In September, the Administration reversed itself, cancelling the KC-10 program as part of a collection of measures designed to reduce the budget for defense purchases. The Congress chose to override the Administration proposal, however, purchasing four of the tankers in fiscal year 1982 and thereby keeping the program alive at least through 1983. 5/

5/ To date, the Congress has authorized purchase of 16 KC-10s. The contract with McDonnell-Douglas provides favorable discounts for up to 44 more aircraft, though it remains in force only through 1983. The Administration's announcement to purchase additional KC-10s did not discuss the precise contractual arrangement, though it did presume some discounts.

Coming back to the Congress' most recent stance, the Administration has again turned its interest toward the KC-10--this time, however, as a component of an airlift enhancement program announced with the fiscal year 1983 budget request. The Administration intends to purchase 44 more KC-10s over the next five years, bringing the total inventory to 60 aircraft. Though the KC-10 has substantial cargo capabilities and is being proposed primarily as a cargo transport, this study evaluates its tanker features in the context of alternative modernization approaches.

KEY CHOICES BEFORE THE CONGRESS

The 97th Congress is facing fundamental decisions that will determine tanker requirements and resources through the remainder of this century. The three tanker modernization proposals noted above have been put forth for different reasons. Nonetheless, in combination, they become competitors, as DoD seeks to meet expanded tanker requirements in coming years.

In choosing among these alternatives, the Congress must consider what tanker capacity the Air Force will need in the future and what mix of the choices possible might best meet various levels of demand. To provide a background for evaluating the three tanker alternatives' performance in both strategic nuclear and conventional non-nuclear missions, Chapter II of this study outlines the tanker needs for the evolving fleet of strategic bombers, as well as for an important representative conventional mission, over the next dozen years. Chapter III notes the relative effectiveness of the tanker alternatives and suggests three alternative investment strategies for meeting future demand for aircraft.

AIRCRAFT

Advanced Technology Bomber (ATB): A new bomber being developed by the Air Force that would incorporate the latest in design and materials technology to minimize chances of radar detection.

B-1B: An updated form of the B-1 bomber, the new B-1B will have better payload and range characteristics than its predecessor and reduced visibility to radar detection. It will be able to carry cruise missiles as well as short-range weapons.

B-52D,G,H: The mainstay bombers of the Strategic Air Command, the B-52s were last delivered in the 1960s. Though updated through the years with new components, the aircraft fleet currently averages nearly 25 years of use. The Administration intends to continue modification plans to fit G and H model aircraft with cruise missiles during the 1980s. The earliest model--the D--will be retired during the next two years.

C-5/C-141: Long-range military transport aircraft capable of airborne refueling.

KC-10: The military designation for a modified form of the commercial McDonnell-Douglas DC-10 transport. The KC-10 is fitted with equipment so it can function either as a cargo transport or as a tanker for aerial refueling.

KC-135A: The Air Force's primary tanker, the KC-135A is a prototype of the commercial Boeing 707. It was first introduced in 1957 to provide aerial refueling for the Strategic Air Command's B-52 bombers.

KC-135E: The military designation for the KC-135 tanker aircraft fitted with JT3D engines.

KC-135R: The military designation for the KC-135 tanker aircraft fitted with CFM-56 engines.

(continued)

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ENGINES

CFM-56: A new generation turbofan jet engine currently being manufactured jointly by General Electric and Snecma, a French firm. The engine, in addition to being used on several new types of aircraft, is being installed as a replacement engine on the commercial DC-8 aircraft. The Air Force plans to install this engine on 300 KC-135A tankers over the next five years.

JT3D: The letter designation of an engine manufactured in the past by Pratt and Whitney. The JT3D was a mainstay engine on the first generation of commercial jet transports. Its military counterpart--the TF-33--is installed on a large number of military aircraft. The Air Force is currently salvaging and refurbishing JT3D engines from some 28 retired Boeing 707s and installing them on KC-135A tankers.

Turbofan Engines: Modern jet engines of which substantial improved efficiency is achieved by having the engine turn very large fans mounted at the front of the engine.

OTHER TERMS

Forward Staging Areas: Bases near the likely area of combat used to manage combat operations of participating forces.

"Penetration" Missions: A term used to describe current bomber operations that would have bombers fly over enemy territory and attack targets with short-range weapons.

"Shoot-and-Penetrate" Missions: A term used to describe bomber missions that combine use of cruise missiles launched from long distances and short-range weapons launched from bombers flying over enemy targets. The mission would typically involve launching ("shoot") cruise missiles first; they would then enter enemy airspace ("penetrate") to launch short-range weapons.

"Stand-off" Missions: A term used to describe bomber operations that involve cruise missiles only; the bomber need not fly over enemy territory but must launch long-range cruise missiles from "stand-off" distances.

CHAPTER II. TANKER DEMAND FOR FUTURE STRATEGIC NUCLEAR AND CONVENTIONAL NON-NUCLEAR MISSIONS

Bomber modernization programs recently announced by the Administration significantly affect the Air Force's tanker needs over the next dozen years. The analysis in this chapter indicates that in the near term--that is, during the mid-1980s--the Air Force faces a substantial shortage of tanker capacity. 1/ In the long term, however, existing tanker capacity will likely prove sufficient. This chapter first discusses the estimated tanker demand over the coming 14 years in light of the recent decisions about bombers. It then examines requisite needs for possible conventional missions. Figure 1 depicts the pattern of projected tanker demand to 1995 as it relates to the current capacity of KC-135A tankers, displaying yearly cumulative demand in terms of existing, or "A", equivalents. Demand estimates above the "current capacity" line on the figure represent projected tanker shortages. Table 1 presents current and projected tanker demand for several critical years.

STRATEGIC TANKER MISSIONS

The Strategic Air Command is responsible for developing a war plan for the 375 bombers and 600-plus tankers devoted to strategic nuclear missions. Called the Single Integrated Operational Plan (SIOP), the SAC plan consists of highly detailed sets of instructions for each aircraft (as well as for land- and sea-based missiles), specifying targets, attack routes, back-up alternate plans, and so forth. The SIOP is not available for public discussion for reasons of national security; as a

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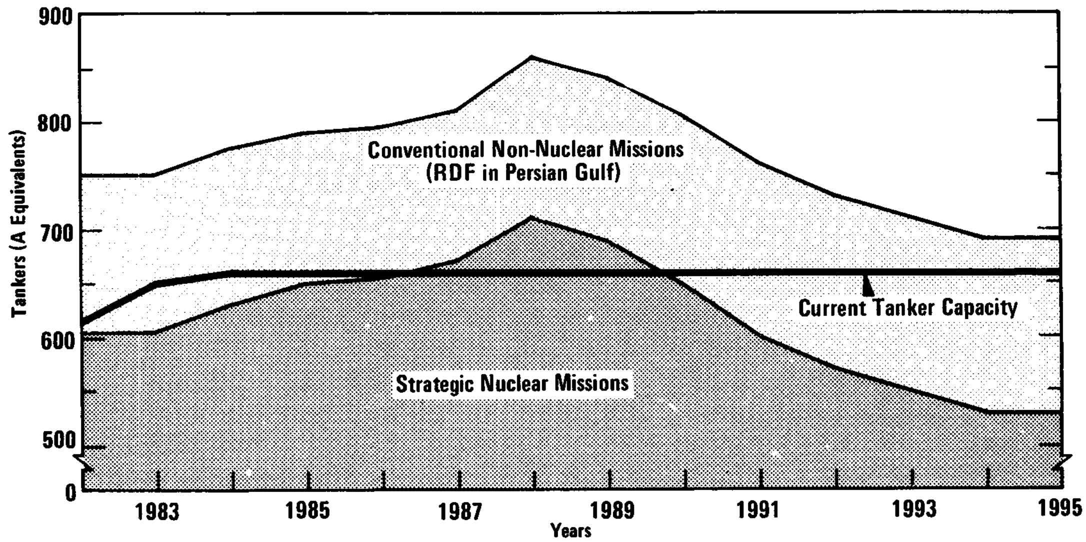
1/ The Congressional Budget Office has developed a quite elaborate technique for evaluating likely future tanker demand. Using computers to "fly" aircraft missions, aerial refueling operations were assessed in both strategic nuclear and conventional non-nuclear missions. Details about the scenarios and CBO computer model used as the basis for this study are given in Appendix A. Further technical details are available from CBO.

Figure 1.

Projected U.S. Tanker Aircraft Demand for Strategic Nuclear and Conventional Non-Nuclear Missions, 1982-1995



SOURCE: Congressional Budget Office.

substitute, a generalized hypothetical attack plan developed by CBO and composed of four generic missions served as the basis for this analysis. (Further discussion is provided in Appendix A.) They are depicted in Figure 2. Bombers were assigned to each mission on the basis of industrial concentration and military installations in Soviet territory.

Bomber Modernization Plans

The Administration recently announced plans to build two new bombers: an updated version of the B-1, to be fielded in the mid-1980s, and an advanced technology bomber incorporating "stealth" technologies, to be fielded in the early 1990s. With the introduction of these two new aircraft, B-52s will gradually be retired from service. In the interim, B-52s will also be modified to carry cruise missiles, continuing the modification plans developed after 1977, when President Carter cancelled production of the B-1 in favor of cruise missiles on the B-52s. The first squadron of B-52G aircraft will stand alert with cruise missiles in December 1982. As noted in the first chapter, that modification program is to proceed in two phases.

TABLE 1. TANKER DEMAND IN 1988 AND 1994 AS MEASURED IN KC-135A AIRCRAFT EQUIVALENTS

	1983	1988	1994
Current Inventory	615	656	656
Total Projected Demand	746	860	687
Strategic Nuclear Missions a/	605 b/	713	528
Conventional Non-Nuclear Missions c/	141	147	159

SOURCE: Congressional Budget Office.

NOTE: Numbers are expressed in terms of Primary Aircraft Authorization (PAA), which slightly underestimate totals.

NOTE: The Air Force does not designate tankers for either strategic or conventional missions. The Strategic Air Command does contend, however, that the KC-10 cannot support strategic mission requirements.

a/ Includes tanker support for command post aircraft and certain reconnaissance aircraft with assigned strategic missions.

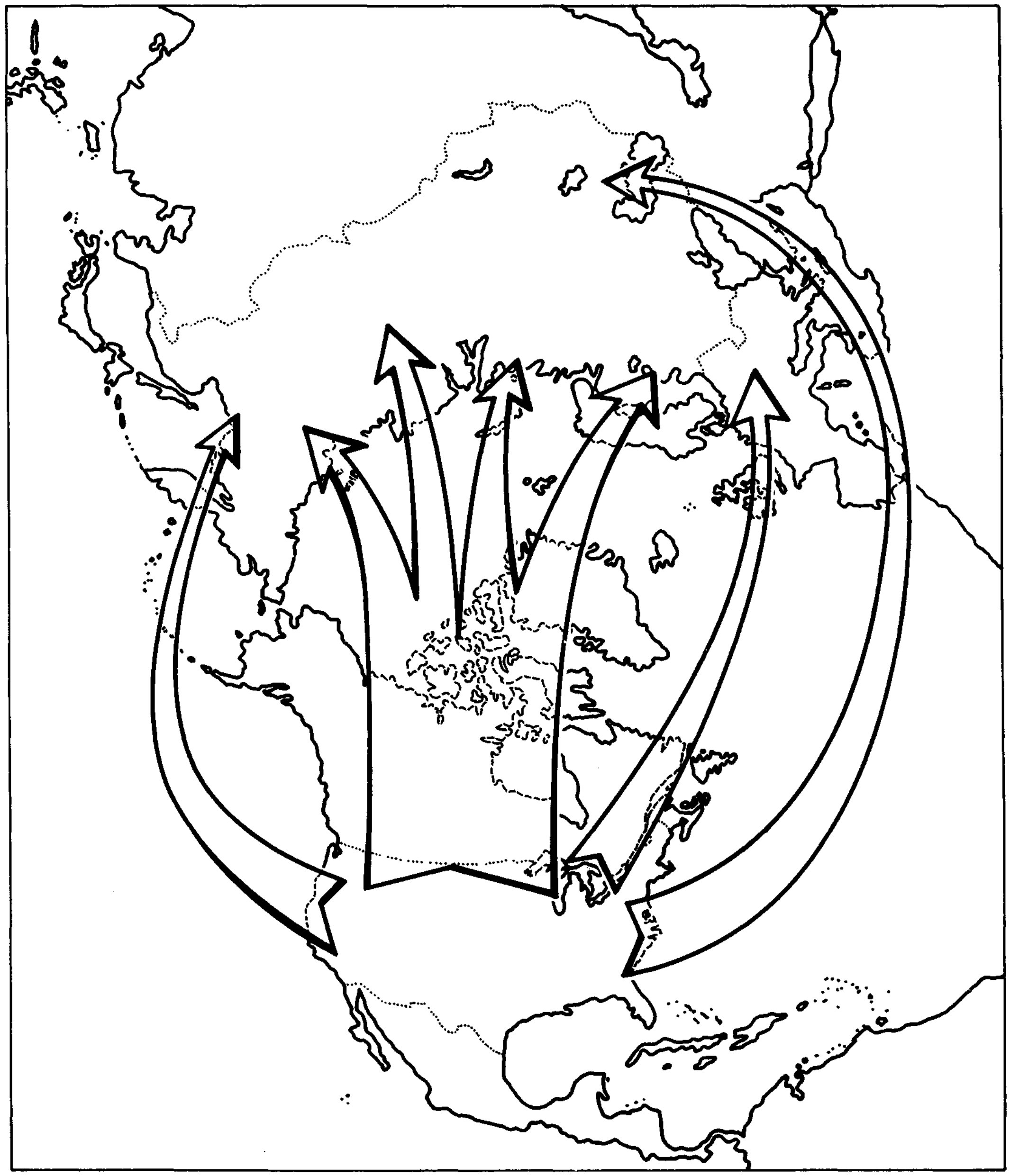
b/ Excludes tanker support for D model B-52s which the Administration intends to retire by the end of fiscal year 1983.

c/ Assumes that the 50 C-5s requested by the Administration will be introduced starting in 1988 and will be fielded by 1990.

The first involves installation of cruise missiles on pylons under the wings, with the internal bomb bays loaded with short-range weapons. The bomber will be capable of first launching the cruise missiles before entering enemy airspace and then continuing at low altitudes to launch short-range weapons against other targets. This is often called the "shoot-and-pentrate" mission. (Currently, bombers fly only "penetration" missions with short-range weapons.)

Figure 2.

Hypothetical Attack Missions Used in CBO Analysis of Tanker Aircraft Modernization Alternatives

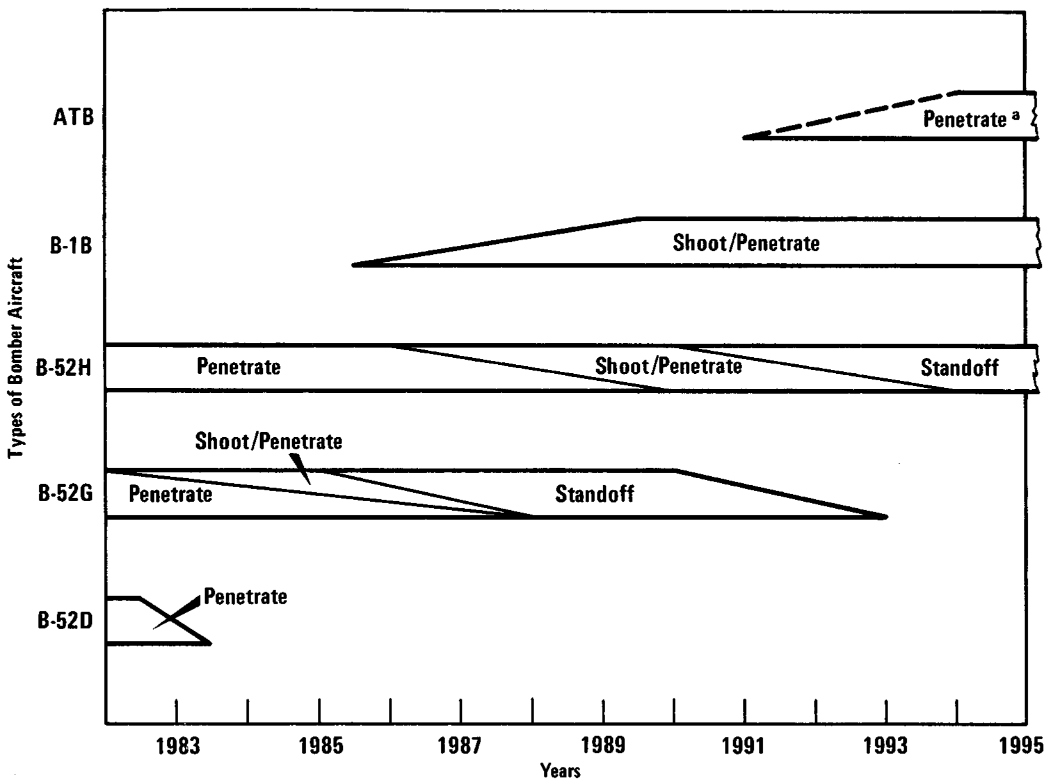


SOURCE: Congressional Budget Office.

In the second phase of the modification beginning in the mid-1980s, cruise missiles are to be added internally in the B-52s bomb bays. At that time, the bombers would not carry short-range weapons that require flight in enemy airspace when Soviet air defenses are presumed to be too taxing for B-52 operations. Since these "stand-off" bombers capable of launching long-range missiles could avoid the long flight at low altitude, tanker and fuel requirements would decline substantially. Figure 3 shows the evolution in strategic bomber forces over the coming 15 years, in light of the Administration's modernization plans. Though these plans obviously can change if circumstances or policies change, they represent the general plans for modification and retirement of B-52s and introduction of the new bombers.

Figure 3.

Projected Development of U.S. Bomber Forces and Missions



[a] Projection uncertain because no precise delivery schedule for the ATB aircraft is available

SOURCE: Congressional Budget Office, based on Department of Defense Annual Report, FY 1983.

Evolving Tanker Demand in Light of Bomber Modernization

Tanker needs will increase until the end of this decade, primarily because B-52s are to be converted to carry cruise missiles and fly shoot-and-penetrate missions through the 1980s. Figure 1 therefore shows the requisite number of tankers for strategic missions over the next 14 years, in light of the Administration's modernization plans. The increasing level of tankers required is caused by the cruise missile modification to the B-52s. Bomber inventories through the mid-1980s remain unchanged. Rising tanker demand could be offset considerably with a change in the cruise missile modification program by installing cruise missiles internally and having "stand-off missions" only for B-52s. Such a program alteration has some far-reaching potential, though possibly some unacceptable military implications as well. The shoot-and-penetrate mission profile is extraordinarily taxing, increasing average tanker requirements by 34 percent for each bomber affected. In 1982, SAC would require nearly all its 615 tankers to provide aerial refueling. 2/ By 1988, this number climbs 18 percent to 713--near the peak of tanker demand--with no effective change in bomber force levels. This increase in demand could be reduced somewhat if the Air Force chose to leap-frog the shoot-and-penetrate stage when possible and fly stand-off missions entirely as soon as cruise missiles become available.

Longer-term tanker demand, however, presents an entirely different picture. As the B-1B and ATB are fielded, and the B-52s are retired from service or become stand-off cruise missile carriers only, tanker needs will decline greatly--in fact, to levels so low that current tanker capacity would be adequate (again, see Figure 1 and Table 1). This reduction is attributable to two factors: there will be fewer B-1 and ATB aircraft altogether than the current fleet of B-52s; and according to Air Force estimates of performance, the new aircraft engines will have substantially better fuel efficiency. 3/ Long-term tanker demand

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2/ SAC tanker needs would be higher because it still provides tanker support for D model B-52s. The Administration has announced its intention to retire D model bombers by fiscal year 1984. Thus, they are excluded from this analysis.

3/ Performance characteristics for ATB engines are classified. For study purposes, the ATB is presumed to have the same performance characteristics as the B-1B.

thus appears not to be substantial. This could change, however, if the Defense Department were to retain B-52s well into the 1990s, which it might do either to expand force levels or to compensate for problems with either the B-1B or the ATB. At present, however, the justification for expanding tanker capacity turns on meeting short-term shortages.

CONVENTIONAL TANKER AIRCRAFT MISSIONS--SUPPORTING THE RAPID DEPLOYMENT FORCE

Aerial refueling missions now figure prominently in Defense Department plans for a conventional NATO conflict, as well as for important non-NATO contingencies. Tankers would be used not only to support fighters and transports on the way to the theater of combat, but also in battle to augment operations of tactical fighters. With aerial refueling, fighters nearing empty but still carrying unexpended weapons can stay on station for longer periods. And in some missions, B-52s with conventional non-nuclear weapons would possibly be used. These factors could add to tanker demand.

Tanker requirements for non-nuclear contingencies cannot be estimated with the precision one can apply to strategic missions. Strategic nuclear missions are based on relatively precise and detailed plans that are not designed to be substantially altered once the attack begins. Tactical missions, on the other hand, are far less prescribed and are subjected to substantial spontaneous revision as circumstances of combat dictate.

For purposes of this study, CBO evaluated the tankers needed to deploy the Rapid Deployment Force (RDF) to the Persian Gulf via military airlift and to deliver and support tactical fighter units in theater. The Persian Gulf scenario was selected for analysis to illustrate potential conventional demand for aerial refueling for three main reasons. First, conflict in Southwest Asia--quite possibly in the Persian Gulf region--is considered a serious prospect, and use of the RDF in any such conflict is regarded as an entirely plausible scenario. Indeed, the RDF was conceived for just such a contingency. Second, any involvement of U.S. forces in a Southwest Asia conflict--a situation that would be politically highly charged--could well bring about a recurrence of the problem encountered in the 1973 Arab-Israeli war mentioned in Chapter I, namely, the refusal of nations between the United States and the Middle East to allow U.S. aircraft to land for refueling. The likelihood of this problem's repeating itself points clearly to a potential need for tanker support for a contingency involving the RDF. And third, the other main theater of possible (though less probable) conflict envisioned by the Defense Department--Europe, where a NATO-Warsaw Pact war would take place--is close enough to the United States to obviate any great need for tanker support for conventional U.S. forces except for transporting tactical fighters in the opening days of a mobilization. 4/ Though additional refueling capacity would be useful, tanker resources adequate to support the RDF as projected here would probably be sufficient to support scaled-back though essential requirements of a European conflict.

In the model used for this study, all airlift sorties using the C-5 and C-141 transports receive aerial refueling. 5/ Tankers were also used to ferry four tactical fighter wings to the theater of conflict. Those same tankers were also used to support fighter operations in theater. 6/ Rapid Deployment Forces might include strategic bombers flying non-nuclear missions too, as well as certain reconnaissance and special-purpose aircraft. Those aircraft would come from strategic nuclear force inventories. Tankers for those aircraft were included in the above analysis.

As noted in Table 1, this analysis indicates that, in the early 1980s, some 141 tankers would be needed to support the RDF in a Persian Gulf deployment, and 159 in the 1990s. The increase is caused by the addition of 50 C-5 transport aircraft to the airlift fleet, as proposed recently by the Administration. Obviously, the addition of more tactical fighter squadrons to the RDF could increase requisite tanker needs somewhat, though this

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4/ The number of tankers needed to support a full-scale NATO conflict in Europe is potentially much larger than estimated here, since there are substantially greater forces involved, especially tactical fighter wings which must be deployed across the Atlantic in the opening days of mobilization.

5/ Study results shown below presume tankers can be based at intermediate staging areas, which is a frequent study parameter. The CBO model can evaluate restrictions that limit tanker basing to U.S. or theater fields as well.

6/ The commander of the Rapid Deployment Joint Task Force has indicated that as many as four tactical fighter wings would accompany RDF operations.

estimate appears reasonable to support current levels of conventional demand in a Persian Gulf contingency. As displayed in Figure 1, in the long term, current tanker resources would be adequate to support both strategic and conventional operations. In the interim, however, the shortage of tanker resources implies that the Defense Department will, over the next five years at least and maybe for longer, face a difficult trade-off, if conditions should arise that necessitated use of tankers for conventional operations. Those tankers become available only at the potential expense of strategic missions.

TANKER SHORTAGE AN ISSUE OF TIMING

The problem of tanker "shortages," then, is a timing issue; tanker modernization alternatives should therefore be evaluated in this context. Obviously, the Congress could judge that it is willing to accept the risk presented by these tanker shortages, and choose not to expand tanker resources, saving substantial expenditures over the next five years. That course is unlikely, however, since the Congress has of late been instrumental in boosting tanker improvement programs. For the most part, those programs preceded the recent bomber modernization effort, however. Not all alternatives may thus be required, and with different modernization objectives, some alternatives may be more appropriate than others. This is the subject of the concluding chapter.

CHAPTER III. ALTERNATIVE APPROACHES TO MODERNIZING TANKER FORCES

The Air Force has three options for expanding the size and effectiveness of its tanker aircraft fleet:

- o Installing newer generation CFM-56 engines on existing KC-135s;
- o Installing older generation JT3D engines on KC-135s; or
- o Continuing to buy KC-10 advanced tankers.

As a guide for considering what course the Congress might take concerning the tanker fleet, this chapter evaluates the relative effectiveness of these options. It concludes with three strategies for meeting future tanker needs.

PERFORMANCE IMPROVEMENTS WITH TANKER MODERNIZATION ALTERNATIVES

The most widely used method for comparing tanker alternatives is by their respective fuel delivery capacities. It is on this basis that Air Force spokesmen have indicated that the CFM-56 turbofan engine improves performance of the KC-135A tanker by 50 percent, that the JT3D engine by 20 percent, but that the KC-10 aircraft is three times better than a current KC-135A. The Air Force estimates are based on the fuel delivery capacities at a specific hypothetical distance. Such a single measure, however, fails to account for the ranges and diversity of types of missions and the operating conditions and restrictions that can affect tankers' relative performance.

Using the computer model and scenarios developed by CBO (described in the previous chapter and Appendix A), the analysis here goes beyond fuel delivery capacities to evaluate the three tanker alternatives. On the basis of specific flight and fuel performance data provided by the Air Force, each tanker was "flown" in all missions in support of all types of receiver aircraft, subject to the same assumptions and restrictions used to establish overall tanker demand. This method of analysis not only permits direct comparison of three tanker alternatives; it also indicates the incremental (or "marginal") contributions of additional modified tankers.

Table 2 compares the average performance improvements based on the method used by CBO to the Air Force estimates of performance. The CBO estimate is based on use of each respective tanker in all types of missions over each of the 14 years of this study period with the force structure likely to be in place as noted in the previous chapter. Figure 4 shows the year-by-year average effectiveness of the three alternatives. 1/ This analysis reveals several major points.

TABLE 2. CURRENT TANKER AND THREE ALTERNATIVES--AIR FORCE AND CBO MEASURES OF IMPROVED TANKER PERFORMANCE

Tanker	Air Force	CBO Analysis
KC-135A (Current Tanker Aircraft)	1:1.00	1:1.00
	(Improvement Ratios)	
KC-135R Aircraft with CFM-56 Engine	1:1.50	1:1.43
KC-135E Aircraft with JT3D Engine	1:1.20	1:1.19
KC-10 Aircraft	1:3.00	1:2.76

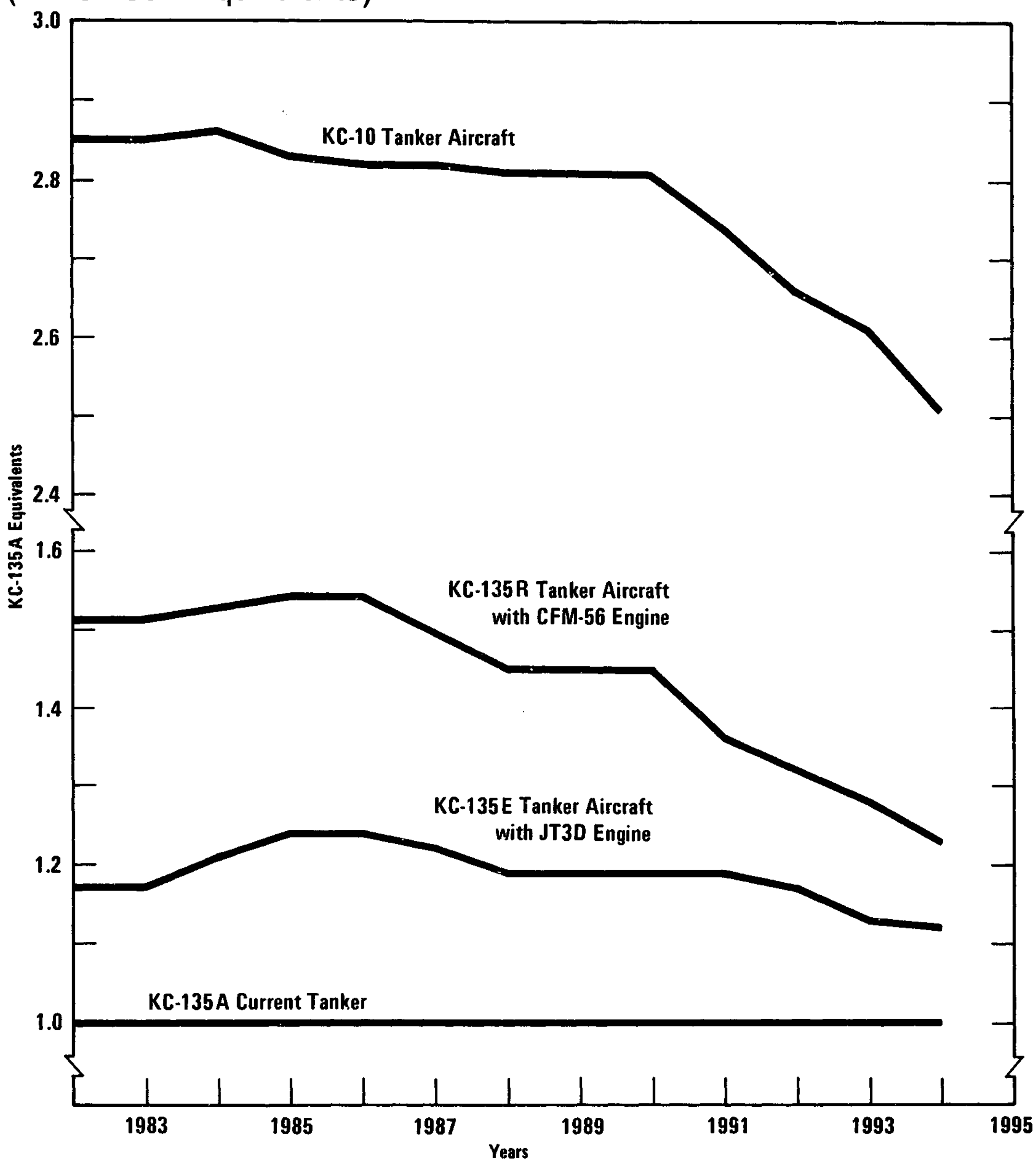
SOURCE: U.S. Air Force and Congressional Budget Office.

NOTE: Improvements expressed in KC-135A equivalents.

1/ The curves are hypothetical, since they presume all missions are flown by that single type of aircraft that year.

Figure 4.

Year-by-Year Performance Improvement of Tanker Aircraft Alternatives (In KC-135A Equivalents)



SOURCE: Congressional Budget Office.

Average Performance Improvements

First, according to CBO's evaluation, all the alternatives listed at the outset of this chapter are likely to fall short of the Air Force's performance improvement estimates. As noted above, Air Force claims for each alternative are based on comparison of fuel delivery capacities. The CBO analysis, by introducing specific (though hypothetical) missions and controlling for the anticipated development of the bomber force, indicates that improvement would be somewhat less if tankers are flown in the full range of likely missions and subjected to specific operating restrictions.

Second, although the table indicates the average performance over the 14-year projection period, the figure shows that there is a definite trend among all tankers for performance under all three types to decline in relative terms. This is the direct result of the evolution of the bomber force, with the gradual retirement of less fuel-efficient bombers (less fuel-efficient receivers boost the utility of tankers) and the introduction of the somewhat more fuel-efficient ones. Through the early- to mid-1980s, the CFM-56 is expected to perform as well as Air Force estimates or better. The relative utility of the CFM-56 diminishes, however, as B-52s retire and a newer, smaller, and more efficient fleet of bombers is fielded. The bulge in the JT3D curve in Figure 4, between 1983 and 1988, is directly related to the B-52's use in shoot-and-penetrate missions, which are particularly demanding in terms of tankers and for which the JT3D is well suited. At the end of the study period, the relative utility of the JT3D declines dramatically.

"Marginal" Contribution of Tanker Alternatives

This phenomenon of declining relative utility is particularly important, since fielding new or modified tankers will take a number of years. Indeed, current modification programs produce no substantial numbers until near the end of this decade when, in relative terms, the tankers would be substantially less useful than if they had been available earlier in the decade. As such, it is particularly important to examine the marginal effect of adding further increments of tanker capacity.

The CBO's marginal analysis indicates that the greatest utility for tanker modernization is over the next six to eight years. For this analysis, CBO examined marginal effects for two critical years--1988, at the peak of tanker demand and utility, and 1994, when B-52s would be retired and the new generation of bombers operational. Table 3 shows the marginal utility of adding successive increments of 50 re-engined tankers of the two types considered in these two important years. Both tanker types appear to perform much better in 1988 than in 1994, as also indicated in Figure 4. For the CFM-56 alternative, up to 250 tankers offer 50 percent performance improvement or better in 1988. In 1994, however, only the first 50 would offer that performance. The relative utility of the remaining 250 tankers would decline substantially. The same, though more extreme, effects hold true

TABLE 3. TANKER RE-ENGINING OPTIONS--MARGINAL IMPROVEMENT OF SUCCESSIVE INCREMENTS OF RE-ENGINED AIRCRAFT (In percentage improvement per tanker per increment)

Increments of Modified Aircraft	CFM-56 Engine		JT3D Engine	
	1988	1994	1988	1994
1-50	67	50	33	25
50-100	67	33	33	20
100-150	55	30	25	20
150-200	50	25	25	15
200-250	50	25	25	a/
250-300	33	10	20	a/
300-350	33	a/	20	a/
350-400	33	a/	20	a/
400-450	28	a/	10	a/

SOURCE: Congressional Budget Office.

a/ In terms of fuel delivery, there is no effective improvement over KC-135As.

for the JT3D. Indeed, if the program is designed to meet 1994 requirements only, there is no apparent performance advantage for re-engining more than 200 tankers with JT3D engines.

COST EFFECTIVENESS OF TANKER ALTERNATIVES

The performance improvement comparisons shown in Tables 2 and 3 present only part of the story, because the costs of the alternatives vary dramatically. Table 4 shows the cost effectiveness of the three alternatives--that is, the cost to provide one KC-135 tanker equivalent. Table 5 shows the total "life-cycle" costs of providing 100 KC-135A tanker equivalent capacity. Since all three alternatives have greater capability than the current

TABLE 4. INVESTMENT COST OF ADDITIONAL TANKER EQUIVALENTS (Based on average improvement of alternatives)

		In millions of 1983 dollars	
Option	Average Improvement (percent)	Average Investment Cost	Investment Cost per Tanker Equivalent
KC-135R Aircraft with CFM-56 Engine	43	20.0 a/	46.5
KC-135E Aircraft with JT3D Engine	19	7.2 a/	37.9
KC-10 Aircraft	276	70.0 b/	25.4

SOURCE: Congressional Budget Office.

a/ Includes funds to update subsystems not essential for the engine refit but necessary to keep the aircraft operational over the next 20 years.

b/ Includes approximately $4 million for features to make the aircraft acceptable for strategic missions, such as hardening against electromagnetic pulse.

TABLE 5. LIFE CYCLE COSTS OF PROVIDING 100 KC-135 EQUIVALENTS

	(Billions of 1983 dollars)			
Tanker	Number of Tankers	Investment Costs	Operating and Support Costs a/ (20 years)	Life-Cycle Costs a/ (20 years)
KC-135A Aircraft	100	0.2	4.3	4.5
KC-135R Aircraft with CFM-56 Engine	70	1.5	2.6	4.1
KC-135E Aircraft with JT3D Engine	84	0.6	3.2	3.8
KC-10 Aircraft	36	2.5	2.3	4.8
KC-10 (Equal Flying Hour/ Crewing as KC-135)	36	2.5	1.2	3.7

SOURCE: Congressional Budget Office

a/ Based on 326 flying hours per year for KC-135R and E and 540 flying hours per year for the KC-10. The KC-135 is currently manned at levels--1.27 crews per aircraft--necessary to support strategic missions. The KC-10, however, will have three crews, necessitating a higher level of flying hours for training purposes.

tanker, fewer are needed to provide "equivalent" capacity. In terms of investment, the most cost effective way to expand tanker resources is by purchasing KC-10 advanced tankers.

Table 5 shows two entries for the KC-10. The first assumes KC-10 operations as currently planned, having three crews per aircraft and 540 flying hours per year. All versions of the KC-135 have 1.27 crews and 326 flying hours. If the KC-10 is compared with comparable assumptions, life-cycle costs are slightly lower than costs for the re-engined KC-135s. In life-cycle cost terms, the CFM-56 and JT3D options are roughly equal. The higher investment cost of the CFM-56 is offset by expected operating savings.

Though these measures of costs and effects are useful as general guides, the tanker alternatives have different costs and effectiveness, depending on when they are implemented. Thus, the chapter concludes with three specific strategies that might be adopted as tanker modernization plans.

ALTERNATIVE TANKER FLEET MODERNIZATION STRATEGIES

Option I. The Administration Program

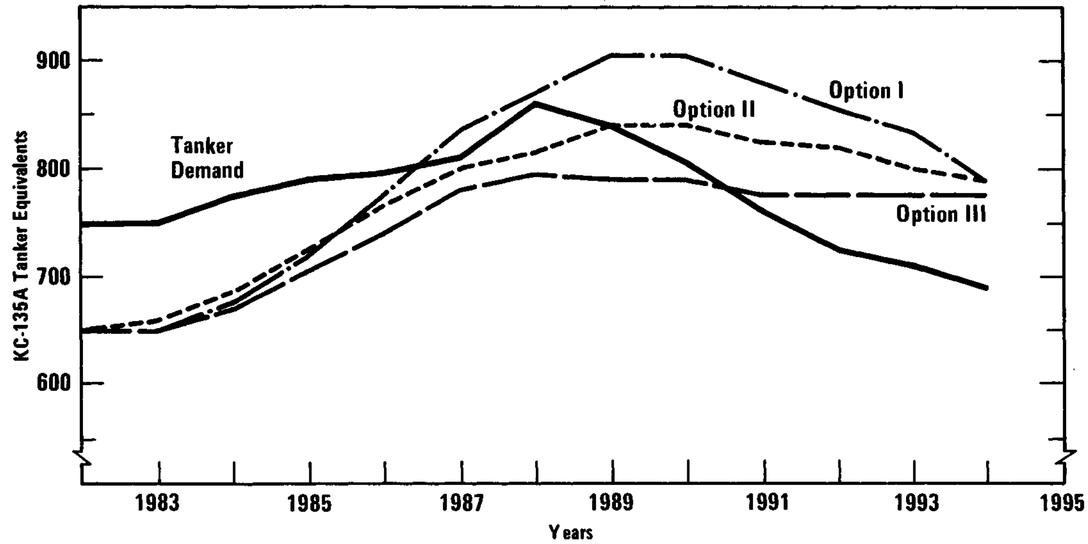
The Administration has announced its intention to proceed with re-engining a portion of the existing fleet of KC-135 tanker aircraft with the CFM-56 engine as the primary means to meet future tanker needs. It has also announced its intention to purchase an additional 44 KC-10 transports, but to use them primarily to supplement airlift resources. Since the KC-10 was sought initially as a tanker, it will be purchased with these features intact, and will have crews trained in aerial refueling procedures, the KC-10 is evaluated here for its potential as a tanker. Table 6, a summary of the costs of the three options, shows the procurement profile for both programs, which together cost $8.5 billion over the next five years.

Figure 5 shows the estimated effect of the Administration tanker modernization program in meeting expected tanker demand. The Administration's program would fall short of meeting tanker demand in the early- to mid-1980s, meeting projected tanker needs only by 1987. In the 1990s, when requisite tanker needs begin to lessen, capacity will substantially exceed demand.

If the Administration carries out its program over the next five years and refits 300 KC-135s with CFM-56 engines, further re-engining would not be needed. (See Figure 5, which depicts the effects of the three modernization options shown in Table 6 with respect to projected demand.) This is because the modified tankers would become available only after tanker demand drops in the 1990s. Air Force spokesmen have already announced their goal of re-engining the entire fleet of 615 KC-135s, however. (That is not currently an official policy of this Administration.) As Figure 5 implies, extending the Administration's program beyond 300 would provide substantial excess capacity in the 1990s. Some

Figure 5.

Projected U.S. Tanker Aircraft Demand and Alternative Modernization Options, 1982-1995



SOURCE: Congressional Budget Office.

of that excess capacity could be used profitably, as an extra margin of flexibility for both bombers and tankers, and as a hedge against future improvements in Soviet air defenses. It could also be held in reserve in the event of additional contingency operations, such as simultaneous NATO and Persian Gulf conflicts (what the Defense Department terms a one-and-one-half-war scenario), though the precise implication and plausibility of such developments is quite uncertain. Also, should problems develop in production and delivery of B-1B bombers, B-52s could be retained for longer periods, lengthening the period of high demand for tanker support.

To reduce excess tanker capacity, the Defense Department could choose to retire unmodified tankers starting in 1990. Retiring excess tankers could result in substantial savings, especially in terms of life-cycle costs, since the cost of operating a tanker for 20 years is estimated to reach $43.2 million in fiscal year 1983 dollars.

TABLE 6. UNIT PURCHASES AND PROGRAM COSTS FOR ALTERNATIVE TANKER MODERNIZATION PROGRAMS

Cost Component	Through 1982	1983	1984	1985	1986	1987	Total
		Option I--The Administration Program					
Procure KC-10 Aircraft	18 a/	8	8	8	8	10	60
Refit KC-135 Aircraft with CFM-56 Engine	9	25	58	64	72	72	300
Cost (billions of 1983 dollars)		1.47	1.84	1.80	1.78	1.57	8.45
		Option II--Lower Cost Modernization					
Procure KC-10 Aircraft	18 a/	8	8	8	8	10	60
Refit KC-135 Aircraft with JT3D Engine	28	48	48	48	13		185
Cost (billions of 1983 dollars)		1.18	0.85	0.80	0.53	0.41	3.77
		Option III--Procure KC-10 Aircraft Only					
Procure KC-10 Aircraft	18 a/	12	12	12	6		60
Cost (billions of 1983 dollars)		1.13	0.76	0.65	0.27		2.81

SOURCE: Congressional Budget Office.

a/ Assumes the Congress endorses the Administration request for two KC-10s in the fiscal year 1982 supplemental appropriation.

Option II. Matching the Administration Program Performance at Lower Cost

The previous section of this chapter noted that the JT3D engine, while less capable than the CFM-56 alternative, is dramatically more cost effective. It also indicated that both re-engining alternatives would become much more useful in the mid- to late-1980s, when tanker demand is projected to peak. The Congress could choose to re-engine the KC-135 with the JT3D engine, almost matching the Administration program in terms of meeting tanker needs, yet saving an estimated $4.7 billion over the next five years. This option would re-engine 185 KC-135s using older generation JT3D engines, and would cost $3.8 billion over the next five years--less than half the $8.5 billion cost of the Administration program.

This alternative would provide the capabilities of Option I through 1986 (see Figure 5). After 1986, the performance of the two options would diverge, but this is after the point when either choice could largely meet the demands of the scenarios studied here. These performance differences could be important if the B-1 is delayed, causing B-52s to be kept in service longer, requiring more tanker support than is shown in Figure 5. Similarly, should conventional non-nuclear demand for tankers be greater than projected here, the differences in performance might be significant. If Air Force production plans hold, however, after 1990, either alternative is projected to provide sufficient capacity to meet estimated demand. Although this alternative fails to meet the tanker shortfall in the early to mid-1980s, it provides nearly as much capacity as the Administration's alternative.

Critics of the JT3D alternative have questioned the availability of salvaged aircraft for use by the Air Force. The House Committee on Appropriations indicates that, of the more than 400 commercial 707s currently in service, some 200 are estimated to become available for salvage over the next five years--the number this option would require. Indeed, if noise and air pollution regulations remain in force, none of the 400 707s with JT3D engines would be permitted to operate in U.S. airspace after 1985. This should improve prospects for obtaining used aircraft, because they could not be used in commercial service.

Critics have also noted that the condition of the used planes' engines is uncertain. The Air Force actively explored opportunities to purchase some 96 used 707s from commercial U.S.

carriers, almost half the aircraft needed under this option. Maintenance records and standards on those aircraft have been examined, leading Air Force spokesmen to declare the planes usable. All engines could be refurbished at modest costs (which have been included in the calculations for this option). It might prove more expensive to refurbish aircraft engines beyond the original 96 proposed earlier by the Air Force. That higher cost would probably be offset by the likely lower selling price for the aircraft as they approach the 1985 air and noise pollution deadline. This option provides for purchase of 185 aircraft, 89 more than originally sought by the Air Force. But 85 of the aircraft would be purchased on or after the 1985 deadline, when costs should be low indeed.

It should be noted that the JT3D engine does not provide the full potential performance that the CFM-56 does. Neither does it offer the noise and air pollution abatement advantages. (See footnote 3 in Chapter I.) Though this alternative has somewhat less capacity than the Administration's plan, it is dramatically less expensive.

Option III. Limit Tanker Modernization to KC-10 Procurement

The most effective way to expand tanker capacity quickly is by purchasing additional KC-10 advanced tankers. Indeed, Administration plans to purchase 44 more KC-10s would provide as much tanker capacity as re-engining 300 KC-135As with the more capable CFM-56 engine. As far as the JT3D re-engining program is concerned, the Air Force would have to re-engine the entire tanker fleet with JT3D engines to match the tanker capacity increase provided by the 44 KC-10s. An all-KC-10 alternative would satisfy between 85 and 95 percent of projected tanker needs through the mid-1980s.

The Congress could decide that it is willing to meet the bulk of tanker requirements by proceeding with the KC-10 program and cancelling further re-engining. This would save $5.7 billion over the next five years relative to Administration plans.

Though the KC-10 alternative is potentially a very satisfactory aircraft for use in SAC's conventional non-nuclear war plans (such as to support the RDF in a Persian Gulf contingency), the Air Force insists that the aircraft, as currently outfitted, does not meet SAC's requirements for strategic warfare. Since the KC-10 was purchased primarily for conventional operations, the Air

Force chose not to install certain features that SAC considers essential--such as "hardening" aircraft systems against certain effects of nuclear blasts. The CBO has assumed the cost of those additional features at $4 million per aircraft (certain other analysts would set this figure higher) and included that sum in the purchase prices shown here, to ensure that the aircraft hypothesized for the analysis could be useful for strategic as well as conventional operations.

Critics of this option might also note that, more than the first two approaches, this one relies heavily on the KC-10s. Yet the KC-10s are being bought primarily as cargo aircraft, and so some or all of them might not be available for tanker missions. The first two options clearly compensate more for the lack of the KC-10s. But the KC-10s are very capable tanker aircraft with crews that will be trained in aerial refueling. Thus it seems reasonable that, in crises for which tankers are in short supply, many of the KC-10s will be made available for tanker duties. Either other aircraft or sealift assets would be used to convey needed military cargo.

APPENDIX

APPENDIX A. STUDY METHODOLOGY AND SCENARIOS USED IN CBO ANALYSIS

To conduct this study, the Congressional Budget Office developed a series of computer models to determine aerial refueling requirements for aircraft that fly strategic nuclear and conventional non-nuclear missions. The model, called EXPONENT, was developed in conjunction with the University of California's Graduate School of Public Policy at Berkeley. This appendix describes the model in general terms and specifies the assumptions underlying the scenarios used to evaluate tanker performance and demand.

THE EXPONENT MODEL

The EXPONENT model consists of standard equations for computing fuel consumption, together with non-linear programming to determine optimal refueling distances and combinations of tanker and receiver aircraft. Appendix Figure 1 schematically diagrams the model.

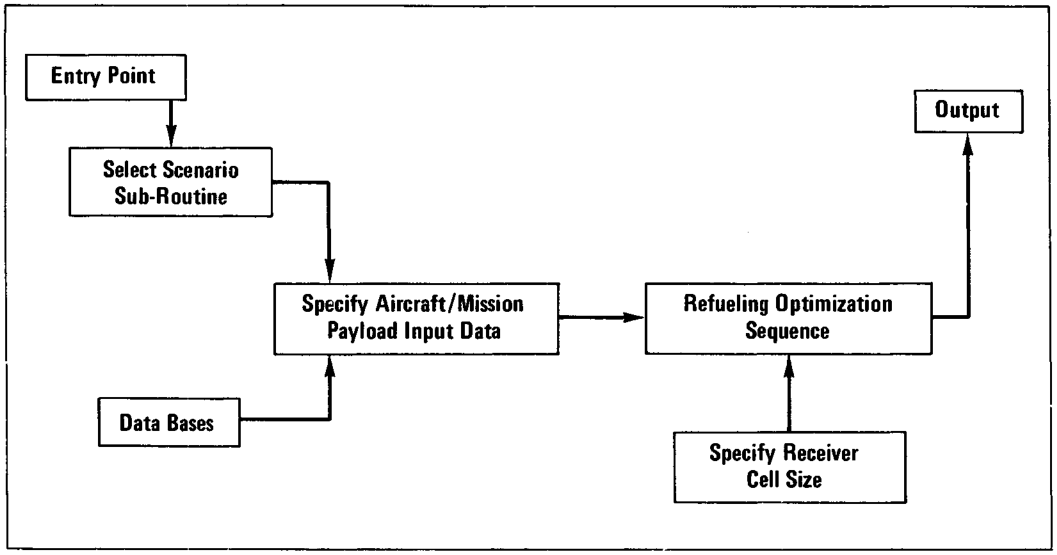
The model's algorithms use Breguet range equations to compute fuel consumption. The equations calculate fuel consumption on the basis of specific factors, including the thrust of the engines, the air resistance of the aircraft (specifically, the lift-to-drag coefficients for the aircraft), the cruising altitude, and so forth. Variables for the equations were derived from data provided by the Air Force for each of the aircraft types examined.

The heart of the model consists of "optimization routines" using non-linear programming techniques. Given specific mission characteristics--such as overall distances, low-altitude distances within enemy airspace, and cruising altitudes--the optimization routine determines fuel reserves needed to accomplish full missions, the best combination of tankers and receiver aircraft, and the distances at which aerial refuelings take place.

The model uses standard Air Force assumptions about payloads, take-off weights, fuel reserve requirements, tanker recovery distances, and so forth. All variables can be changed. CBO conducted checks on all variables to determine the degree to which results were sensitive to specific model assumptions. The model is written in APL.

Appendix Figure 1.

EXPONENT Model Flowchart



SOURCE: Congressional Budget Office.

STRATEGIC MISSION SCENARIO

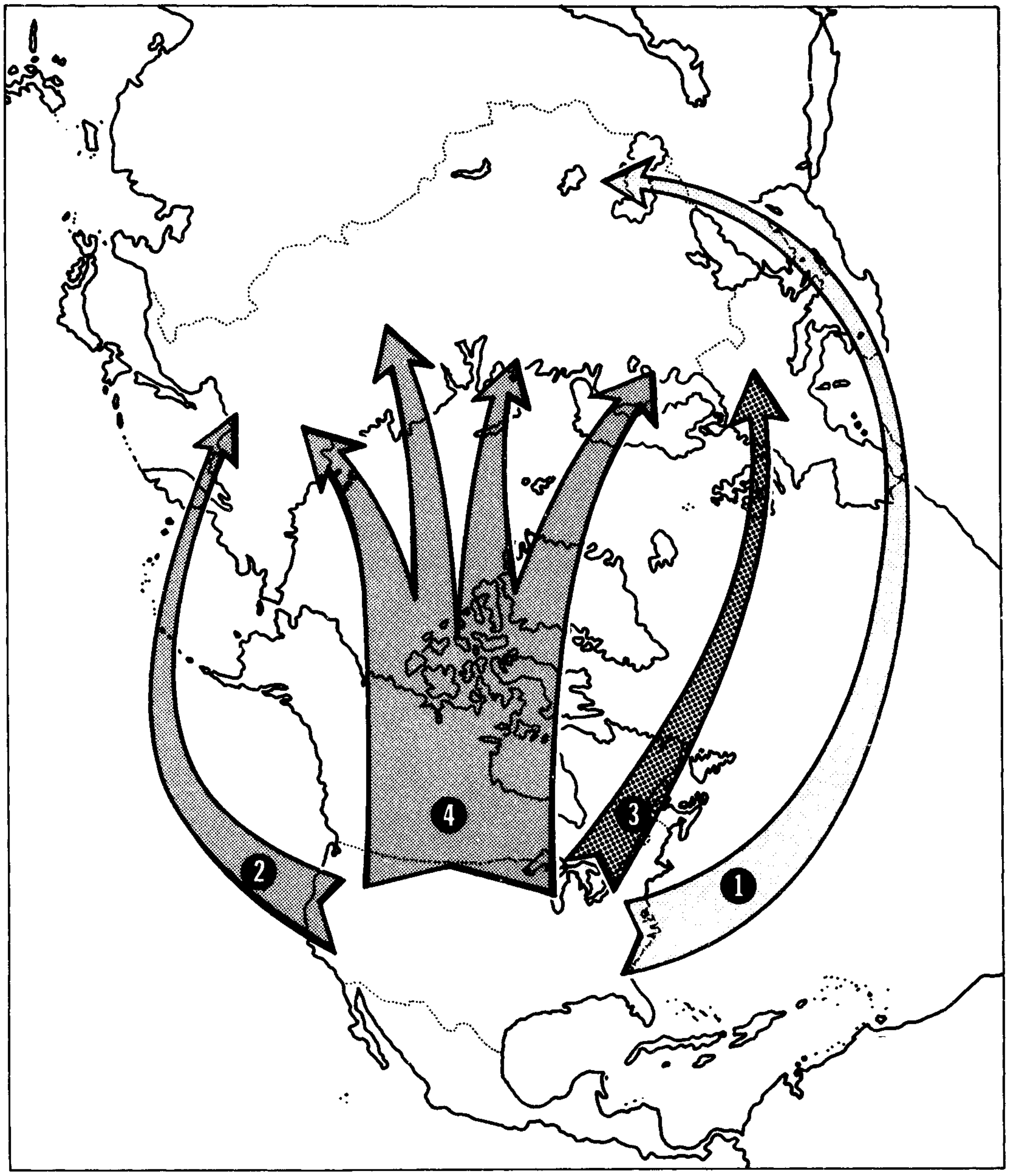
As discussed in Chapter II, the Strategic Air Command is responsible for developing the Single Integrated Operational Plan (SIOP), which contains detailed plans for each strategic nuclear missile and bomber, as well as tanker and other support equipment and units. The SIOP obviously is not available for public discussion. As a substitute, CBO developed a hypothetical scenario for attacking the Soviet Union with bomber aircraft (see Appendix Figure 2). The arrows in the figure represent four generic attack missions:

Mission 1. Bombers fly over the Mediterranean, attacking southern Soviet targets, and return to Turkey;

Mission 2. Bombers fly over the Pacific to attack Pacific Soviet targets, recovering in South Korea and Japan bases;

Appendix Figure 2.

Hypothetical Attack Missions Used in CBO Analysis of Tanker Aircraft Modernization Alternatives



SOURCE: Congressional Budget Office.

Mission 3. Bombers fly over the North Atlantic to attack Soviet targets in eastern Europe and western Asia, with bombers recovering to western European airfields;

Mission 4. Bombers fly over the North Pole to attack central Soviet targets, recovering to unspecified southern airfields.

Specific mileages and flight profiles were associated with each of these attack missions. Bombers were assigned to these missions according to the proportion of targets assumed in each region. Target weighting was based half on industrial concentrations (with population serving as surrogate data) and half on density of enemy military installations. The weighting of the shaded arrows on the figure reflect the relative proportion of bombers assigned to the above missions. By far the highest concentration of targets is found in Mission 3. This study does not specifically allocate bombers by the type of weapon they carry, but allocates them strickly based on numbers of warheads.

It is important to note that this CBO scenario is not based on the SIOP, nor is it intended to shadow it in such terms as targets, options, or attacking aircraft. The scenario is merely designed to provide a general but realistic yardstick for measuring levels of tanker demand and for comparing the performance of alternative tankers.

CONVENTIONAL MISSION SCENARIO

As described in Chapter II, this study evaluated the potential tanker needs associated with a conventional non-nuclear mission involving the Rapid Deployment Force in the Persian Gulf region. The analysis assumed that the RDF consisted of the 18th Airborne Corps and the 24th Mechanized Infantry Division. In addition, the RDF hypothesized by CBO included four tactical fighter wings. The specific designation of units in the RDF was deemed necessary only to determine average payloads for the transports and to establish notional distances for airlift missions. The results in no sense presume "optimality" in deployment.

This scenario assumed that U.S. tankers could stage from intermediate bases, for example at Lajes Field in the Azore Islands. The scenario assumed that 70 (PAA) C-5 and 234 (PAA) C-141 aircraft receive aerial refueling on all outbound sorties.

During the later half of the 1980s, this fleet is assumed to expand to include an additional 45 (PAA) C-5 transports. Those tankers that transport tactical fighters to theater are used exclusively to support those same fighters in theater.

As with the CBO substitute for the SIOP, it should again be noted that the RDF could consist of units other than those specified here. For example, the RDF might include B-52s carrying non-nuclear munitions, as well as intelligence and reconnaissance aircraft requiring tanker support. Those aircraft, including the special-purpose aircraft, are considered under the strategic scenario discussed above. If they are used in an RDF mission in the Persian Gulf scenario, theoretically, they would release tankers, which would no longer be needed in strategic missions; these could accompany them and provide support for conventional operations. As such, while they might well accompany the RDF, they are included in this study in the strategic nuclear scenario and, to avoid double counting, are not specifically denoted here.

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