

ADA 283 909

July 1983

AERIAL REFUELING INITIATIVE

Cross-Service Analysis Needed to Determine Best Approach

AD-A283 909



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94-280/47

National Security and
International Affairs Division

B-253150

July 19, 1993

The Honorable Sam Nunn
Chairman, Committee on Armed Services
United States SenateThe Honorable John Warner
United States Senate

In response to your request for an assessment of the performance of the air refueling tanker force during Operation Desert Storm, we analyzed (1) the relevance, in light of that wartime experience, of a 1990 initiative to enhance tanker efficiency, effectiveness, and interoperability and (2) the adequacy of the Department of Defense assessment of the initiative. Essentially, the initiative called for standardizing Air Force refueling equipment for tankers and fighters on the probe/drogue refueling system used by the other services and many U.S. allies. The tanker modifications would also allow two fighters to refuel simultaneously, a capability known as multipoint.

Results in Brief

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The aerial refueling initiative was not adequately assessed within the Department. Air Force analyses—the basis for the Department's decisions on the initiative—understated proposed benefits and overstated potential disadvantages. Nonetheless, the majority of the actions proposed by the initiative were rejected on the basis of these evaluations.

The Air Force's analyses showed that, compared to its current refueling system, multipoint (1) would not be significantly faster, (2) would cause tanker aircraft to run out of fuel sooner, and (3) would pose operational problems for F-16 and F-22 fighters. The Air Force concluded that these and other obstacles outweighed the new system's ability to refuel two aircraft simultaneously and its interoperability with Navy and U.S. allied aircraft. Conversely, our analysis of Air Force data showed that (1) the amount of time spent refueling from the two systems would be about the same and, therefore, multipoint with twin off-load points would be significantly faster, (2) the Air Force made unrealistic assumptions about tanker loitering times that overstated tanker fuel usage, and (3) reasonable solutions to equipping F-16s and F-22s with the new system may exist. In addition, Desert Storm confirmed the potential benefits of multipoint refueling with the probe/drogue system, including increased efficiency, effectiveness, and interoperability. Such benefits may become more

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important due to continued pressure to downsize force structure and the increased likelihood of joint operations.

The information currently available does not unequivocally support Air Force conversion to the probe/drogue system. The Air Force does have a number of legitimate concerns, not the least of which is its satisfaction with its current system and the cost and effort required to change. By the same token, available information does not provide a sufficient basis for the current decision to exclude the Air Force from converting to the probe/drogue system. Without a full assessment of the initiative's pros and cons from a cross-service perspective, it is not clear how the Department can best meet its aerial refueling needs as it continues to reshape its force structure.

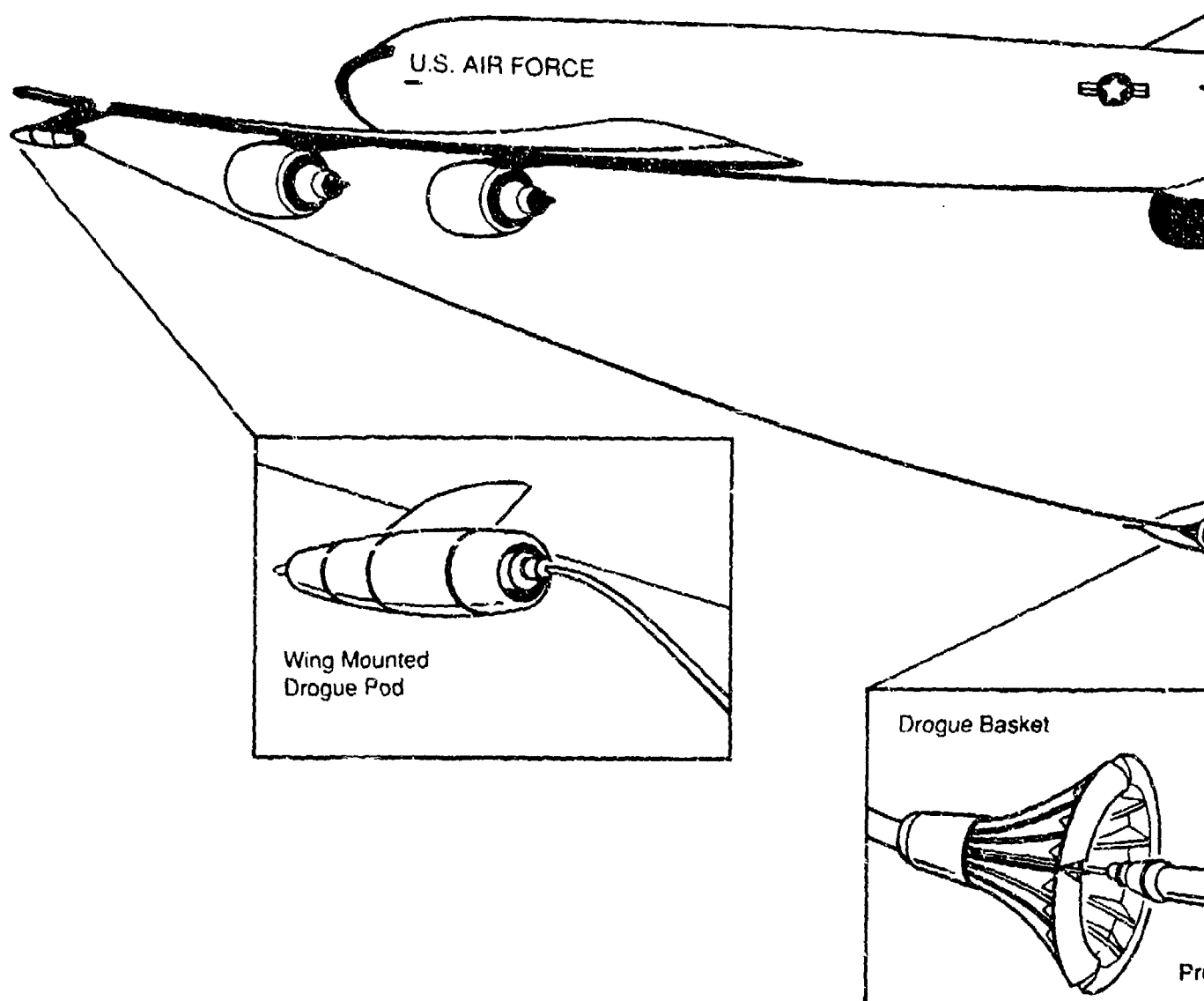
If the Air Force does not increase its participation in the initiative by adding probes to its fighters, it may not be cost-effective to add multipoint to both KC-10s and KC-135s for naval support. The Air Force started a KC-10 multipoint program to support naval refueling requirements in 1987 and now is planning a second KC-135 multipoint program with an identical objective. According to Air Force officials, the planned modification of KC-135s would meet naval needs without the KC-10. Even if equipped with multipoint, the KC-10 may not be available to the Navy because it is in such high demand by the Air Force. If no service will be able to take advantage of the KC-10s multipoint capability, then the program may not be a good investment.

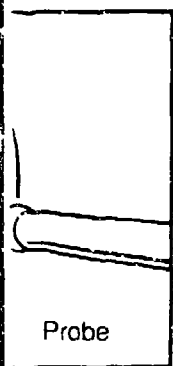
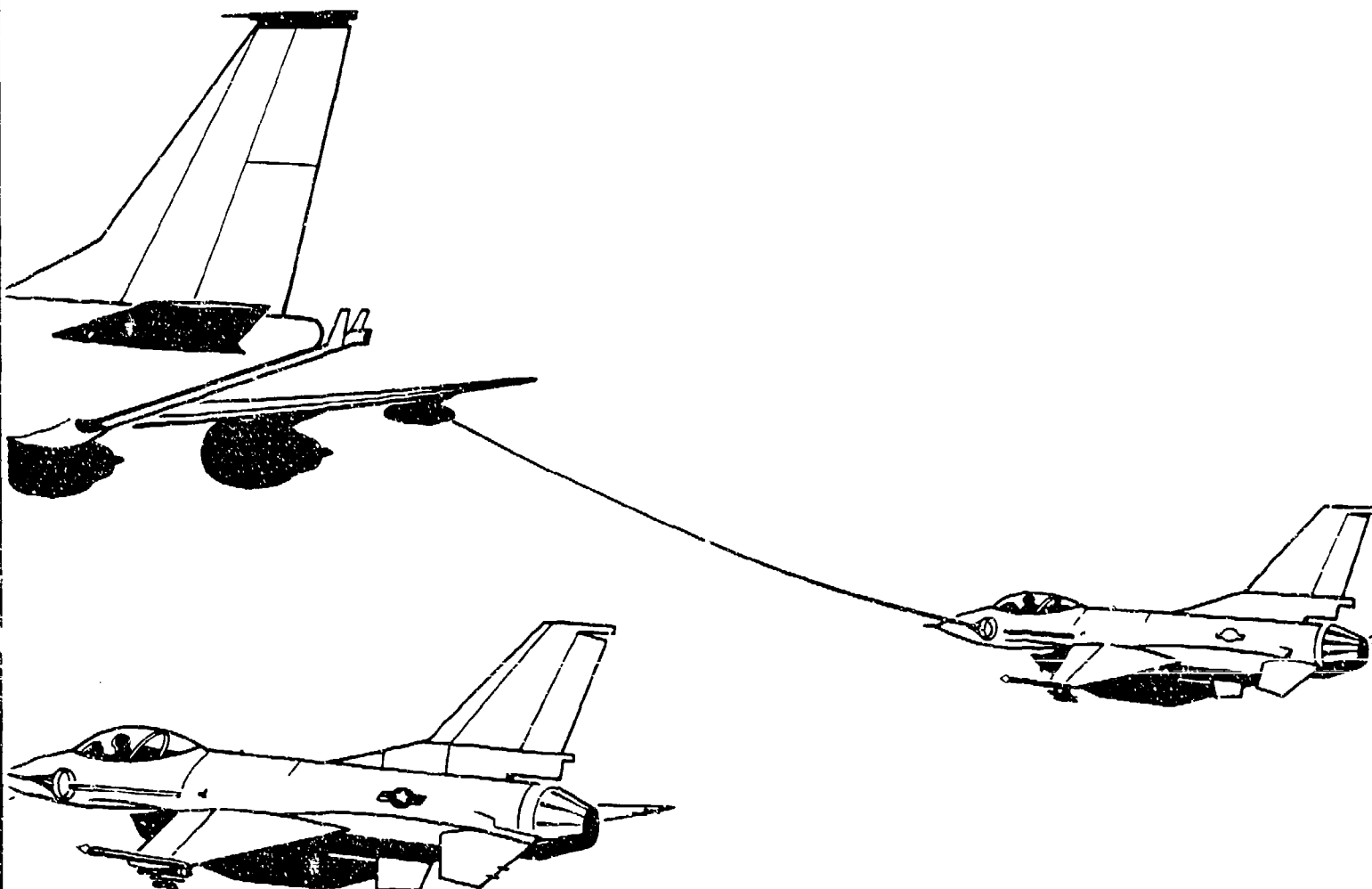
Background

Combat missions by Air Force and Navy fighters often require aerial refueling both en route to and after attacking targets. However, equipment used to accomplish in-flight refueling of fighter aircraft is not standardized within the military.

Navy, Marine Corps, and most U.S. allied fighters use a probe/drogue system. A hose and reel mechanism attached to a tanker aircraft releases a funnel shaped drogue basket connected to a flexible hose. To refuel, the pilot of the receiver aircraft inserts a pipe, called a probe, into the basket. A key advantage of this system is that a "multipoint" tanker fitted with two wing-mounted drogue pods can refuel two fighters simultaneously (see fig. 1).

Figure 1: A Conceptualization of KC-135 Multipoint Tanker Refueling Two F-16s





2

In contrast, Air Force fighters refuel with a boom/receptacle system. The boom is a telescoping tube mounted near the tail of a tanker. During refueling, the boom operator aboard the tanker maneuvers the tip of this tube into a receptacle aboard the receiver aircraft (see fig. 2).

Figure 2: KC-10 Tanker Refueling an F-15



Source: Aerospace Education Foundation.

A boom-equipped tanker can refuel only one fighter at a time. While countries who have purchased Air Force developed fighters also use the boom/receptacle system, over one-half of U.S. and allied air refuelable aircraft (including about 1,700 Navy/Marine Corps aircraft) use the probe/drogue system.

All U.S. fighter aircraft used the probe/drogue system until the Air Force standardized on the boom in the late 1950s. The Air Force's decision was based on the refueling needs of long-range, strategic bombers whose demand for large amounts of fuel could be satisfied more quickly with the boom. At that time, the tactical community within the Air Force strongly resisted switching to the boom since (1) fighters take on much smaller amounts of fuel at a considerably slower rate—a sip as opposed to a gulp and (2) the dynamics of conventional combat (in contrast to strategic nuclear operations) stress flexibility—a capability measured more by the number of off-load points than by the fuel off-load rates or the quantity of fuel available.

A disadvantage of switching to the probe/drogue system is that probes would have to be added to Air Force fighters. There are two basic engineering alternatives to retrofitting fighters with probes: an external design in which the probe is bolted to the outside and covered with a second skin to smooth over the protrusion and an internal approach that completely conceals the mechanism within the fighter's skin. In the 1950s, external probes were added to the Air Force F-80, F-84, F-100, and F-104 and to the Navy A-4 and F-8. The Marine Corps' Harrier as well as the European Tornado and French Mirage have external probes and Israel has also added an external probe to its F-4s. On the other hand, Navy fighters such as the F-14 and F-18 were designed with internal probes.

The Air Force manages most tankers—about 550 boom-equipped KC-135s and 59 KC-10s. The KC-10 has both a boom and a single fuselage mounted drogue, but can only refuel one aircraft at a time. Fifteen KC-10s are being retrofitted with multipoint to support Navy requirements; the first entered operational service in October 1992.¹ Although the Marine Corps manages about 70-drogue equipped KC-130 multipoint tankers, the Navy and the Marine Corps must look to the Air Force if significant tanker support is required.

¹While 20 aircraft are being modified to accept the multipoint drogue pods, only 15 pod sets are being purchased.

Aerial Refueling Initiative

A February 1990 RAND study sponsored by the Air Force identified several ways to enhance Air Force aerial refueling capabilities. In late 1990, the Secretary of the Air Force acted on RAND's recommendations and initiated a tactical air refueling standardization package. As initially conceived, the initiative consisted of three elements: (1) placing probes on all F-15 and F-16 fighters; (2) incorporating a probe in the design of a future Air Force fighter, the F-22; and (3) adding two multipoint drogue pods to a portion of the KC-135 tanker fleet while retaining the boom off-load point. To provide redundancy and maximum flexibility, Air Force probe-equipped fighters would retain their receptacles. Furthermore, since multipoint tankers would keep their booms, they would still be able to refuel aircraft not outfitted with probes.

According to 1991 Air Force estimates, the \$1.3 billion cost to modify about 3,000 F-15 and F-16 fighters and 250 tankers could be offset by reduced operating and support costs from the retirement of about 26 KC-135 tankers. Cost estimates for the air refueling initiative are outdated since both the number of fighters and tankers to be modified changed as the initiative evolved. For example, the number of fighters decreased due to the planned downsizing of the tactical Air Force and the number of tankers to be modified was reduced to about 150.

Based on RAND's analysis, the rationale behind the initiative was increased efficiency, effectiveness, interoperability, and safety during multiservice/multinational air operations.

Efficiency: During time-compressed operations involving large groups of fighters, fewer multipoint tankers can refuel the same number of fighters as single-point, boom-equipped tankers. Furthermore, since a multipoint tanker can transfer fuel more quickly, the tanker itself consumes less of its available fuel, leaving more fuel available for fighters. The initiative was based on the assumption that the overall increase in efficiency would justify a reduction in the size of the tanker force, offsetting both tanker and fighter modification costs.

Operational Effectiveness: By allowing two fighters to be serviced simultaneously, a multipoint tanker enables more aircraft to be refueled in less time than a boom-equipped tanker. In addition, the overall range of a fighter package would be increased since there would be a smaller difference between the fuel load of the first and last aircraft refueled.² The

²Air Force officials commented that multipoint would either increase tanker efficiency or extend the range of a fighter package but not simultaneously.

RAND study noted that multipoint tankers are better suited than single-point tankers to the stress of conventional air war tactics because they permit enemy defenses to be overwhelmed with a large group of fighters over a brief period of time. This flexibility was considered important given the dynamic and uncertain nature of warfare. U.S. military plans for European, Persian Gulf, and other scenarios anticipate such large, time-compressed attack waves.

Interoperability: Navy or allied probe-equipped fighters can refuel from a KC-135 boom if a drogue adapter kit is attached to the boom prior to takeoff. However, only aircraft with probes can refuel when the kit is in place, which can lead to scheduling and coordination problems as it did during Vietnam and Desert Storm. Multipoint would allow KC-135 tankers to refuel either receptacle- or probe-equipped aircraft on the same mission; since a portion of the tanker fleet would no longer have to be dedicated to supporting naval operations, the overall efficiency of tanker operations would be increased. If the F-15 and F-16 were retrofitted, about 85 percent of Air Force tactical fighters would be probe equipped in addition to all Navy and Marine Corps fighters.

Safety: Multipoint would provide redundancy in overwater deployments since two off-load points would be available. A single KC-135 or KC-10 currently fails to meet the Navy requirement of redundant systems for overwater deployments. Thus, even if one tanker would meet the total fuel requirement for the deployment, an additional tanker must be sent. Moreover, during combat, a group of fighters dangerously low on fuel would have two off-load points rather than one. On the other hand, the design of the currently used drogue adapter kit presents safety hazards resulting in a Navy and Marine Corps preference for the versatile and heavily demanded KC-10. In particular, its metal drogue basket can damage the fighter and the system has a greater tendency to snap off the probe than do more modern designs.

Initiative Significantly Scaled Back

As a result of the Air Force's analysis of the RAND study, the air refueling initiative has been significantly downsized and restructured. As the initiative currently stands, no Air Force fighters will be equipped with probes and 75 KC-135 tankers will be retrofitted with multipoint to better support naval aircraft.

Studies conducted during 1991 by the air staff³ and the Aeronautical Systems Center⁴ concluded that RAND had overstated the benefits of multipoint and that the disadvantages of adding probes outweighed the advantages of the initiative. Based on these studies, the Secretary of the Air Force was advised in December 1991 and February 1992 briefings that the adverse operational impact of adding a probe to the F-16 argued strongly against its modification. Without the F-16, which accounts for about one-half of the Air Force fighter inventory, the air staff concluded that the initiative no longer made sense from an Air Force perspective—that is, the costs, both monetary and operational, outweighed the benefits. Therefore, the air staff recommended that probes not be added to F-15 and F-22 fighters. The Secretary accepted the air staff recommendation on the F-15 and F-22, but because retrofitting the F-15 raised no major concerns, he directed that funding for probes be included in future year budgets.

Several subsequent events served to further distance the Air Force from the initiative. First, the air staff directed the Air Mobility Command⁵ to determine if “100 KC-135 multipoint tankers made sense for naval support.” The Command’s study—conducted without active Navy participation and without consideration of the ongoing KC-10 multipoint program—concluded that only 75 KC-135s were required. The Command recommended that the money saved by putting multipoint on 25 fewer KC-135s be shifted to improvements that would free KC-10 tankers for a dedicated airlift role. Command officials told us that the Navy was invited to participate in the study but declined to do so. Second, the Command recommended a KC-135 multipoint fuel transfer rate based on the rate experienced by naval aircraft refueling from the drogue adapter kit. Some of these naval aircraft can accept fuel at a higher rate. The low rate recommended by the Command reduced the benefit of putting a probe on F-15s and future Air Force fighters. A 1991 Aeronautical Systems Center contract study⁶ had concluded that a higher multipoint fuel transfer rate was the most cost-effective. The multipoint fuel transfer rate is important because a higher rate can decrease the amount of time a fighter spends refueling and, therefore, increase the payoff from the twin off-load points. Officials at both the Air Mobility Command and the Aeronautical Systems

³Air Force Headquarters personnel are referred to as the air staff throughout this report.

⁴Fighter and tanker program offices at the Air Force Materiel Command’s Aeronautical Systems Center are responsible for the procurement and modification of Air Force aircraft.

⁵The Air Mobility Command manages the majority of Air Force tanker assets as well as strategic airlift.

⁶Air Refueling Multi-Point Analysis, Frontier Technology, Inc., Santa Barbara, California, June 30, 1991.

Center indicated that at the time they decided on the lower rate they were unaware that the F-15 was still part of the initiative.

Third, the Senate Committee on Appropriations eliminated research and development funds for the KC-135 multipoint program from the fiscal year 1993 defense appropriations on the basis that the project was "undercut" by the Air Force's decision not to add a probe to the F-16. Finally, after the Secretary of the Air Force left office in January 1993, the Air Force Chief of Staff rescinded F-15 probe funding for fiscal years 1994 and beyond.

Air Force Analysis of Initiative Was Inaccurate

We found that the assumptions used in an air staff multipoint utility study were not well founded and understated the benefits of twin off-load points. Moreover, the technical and operational concerns about retrofitting fighters with probes, particularly the F-16, appear to have been exaggerated.

Air Staff Study Understates Utility of Multipoint

Air Force Studies and Analyses, the in-house analytical arm of the air staff, examined the benefits attributed to multipoint by the RAND study. (We refer to the 1992 Studies and Analyses product as the air staff study throughout this report.) We found that assumptions supplied by the fighter community and used in the air staff study were inaccurate. Without a sound basis, the study penalized multipoint tankers for being slower to refuel fighters, for increasing refueling time when visibility is poor, and for being less efficient on longer missions. The overall impact was an unwarranted reduction in the utility of multipoint tankers. These assumptions are discussed below.

Fuel Transfer Rate: The air staff study assumed that the F-15 and F-16 could be refueled faster with a boom than with a drogue. However, we found that the amount of time a fighter spends refueling from a boom versus a drogue would be about the same and, therefore, multipoint with two off-load points is significantly faster. The study overlooked standard operating procedures that limit the number of boom-equipped tanker pumps that can be activated when refueling fighters. Furthermore, the internal fuel lines of most fighters are too small to accept the maximum boom fuel transfer rates. Thus, the F-15's ability to accept fuel was overstated in the air staff study by as much as 30 percent. The air staff study made two assumption errors regarding the F-16 fuel on-load rate. First, it exaggerated the F-16's capacity to accept fuel from a boom by using a rate 30 percent higher than the published on-load rate. Second, it

misinterpreted data provided by the manufacturer, General Dynamics, and understated the probe-equipped F-16 refueling rate by 17 percent. Together, these errors reduced the F-16 multipoint advantage on the order of almost 50 percent. In briefings, the Secretary was told by the F-16 program office that multipoint would actually increase, rather than decrease, the refueling time for F-16s.

Visibility Assumptions: We found no empirical evidence to support the air staff study's assumption that hooking up with a drogue took almost three times longer than making contact with a boom during periods of reduced visibility—poor weather or at night. The air staff requested no data from users of the drogue system. The assumption was based on several interviews with Air Force pilots who had refueled from drogues rather than with Navy, Marine Corps, or allied aviators more experienced with the system. The study itself used words such as “conjectured” and “subjective” to explain the basis for the assumption. Finally, although modern drogues have lights, the air staff study assumed that drogues could not provide visual cues to expedite nighttime hookups. The Navy, Marine Corps, and other nations that use the probe/drogue system refuel at night and their aircraft generally have lights that illuminate the end of the probe and a certain area forward to facilitate the connection.

Efficiency Assumptions: The air staff study legitimately pointed out that the added weight and drag of drogue pods would reduce the amount of fuel available from a multipoint tanker by about 4 percent compared to a single-point tanker. However, the study then applied added drag only to the multipoint tanker, even though both the drogue basket and the boom create additional drag during refueling. The study used this drag factor, in combination with lengthy loiter and refueling times, to conclude that multipoint tankers are less efficient than suggested by RAND. For example, in a scenario with 1 hour allotted for refueling, the study assumed a 3-hour loiter time that reduced the number of fighters refueled because the multipoint tanker ran out of fuel. In a different excursion, a 3-hour loiter time was also used to conclude that when longer times are available for refueling, more multipoint than single-point tankers are required. However, during Desert Storm, tankers were not scheduled with long loiter times and excess fuel was available on most missions; Air Force officials informed us that tankers arrived on station about 15 minutes prior to scheduled refuelings.

Operational Impediments to Probes Exaggerated

We found that while adding a probe to existing as well as future Air Force fighters would require some trade-offs, the operational obstacles appear to have been exaggerated. For the F-16, an internal probe was ruled out and an external option was deemed operationally unacceptable by the air staff. The air staff also opposed modifying the F-22 and F-15, even though internal probes were feasible.

The F-16 is a highly agile multirole fighter that can be used in either an air-to-ground or an air-to-air role. Even though air-to-air combat is not its primary mission, the Air Force wants to ensure that any modifications preserve this agility. Since an internal probe would have eliminated maneuverability concerns, we asked officials whether an internal probe was feasible. Both General Dynamics and program office officials noted that compared to the F-15, the F-16 is a smaller, more tightly packed aircraft, compounding the difficulty and increasing the cost of an internal solution. Although replacing the F-16's air-to-air gun with an internal probe was feasible, this option was rejected because the fighter community did not want to give up the gun.

The air staff's position that an external probe would unacceptably compromise the F-16's maneuverability prevailed. However, F-16 program office officials characterized the maneuverability concerns resulting from an external probe as "preliminary" and added that none were "showstoppers." Based on past experience with the F-16, program office and General Dynamics officials believe that actual flight testing, rather than laboratory analysis, is needed to determine operational impacts. Even without a probe, the F-16's maneuverability is limited in its primary ground attack role when the fighter is loaded with bombs and external fuel tanks. Jettisoning those loads restores its agility and, thus, its advantage over other aircraft in air-to-air combat.

The program office and the air staff raised several additional operational concerns about adding a probe to the F-16. We found that the proposed design—culled from more than a dozen potential external configurations—addressed most of those concerns. For example, the probe would be mounted on the top, left side of the aircraft where the wing and fuselage join. As with other single-engine aircraft such as the Marine Corps' Harrier, this upper wing location would minimize the chance of a detached drogue basket being sucked into the engine.

In a February 1992 briefing on the F-22, the head of the Aeronautical Systems Center told the Secretary of the Air Force that retaining the

receptacle and adding an internal probe would have a "major impact" on the fighter's range. We found that though slightly reducing the range of the fighter, the probe also reduced weight since it displaced up to 500 pounds of fuel. Although the F-22's fuel capacity and range are classified, we were told that 500 pounds of fuel equates to about 50 miles for an F-15. This trade-off may be acceptable because throughout the design of the aircraft engineers were repeatedly tasked to reduce weight to meet maneuverability criteria. F-22 program officials noted that the longer the delay in making a decision on adding probes, the greater the cost. For example, when the refueling initiative was first proposed in late 1990, the internal configuration of the aircraft was just being addressed. Now, 2 years later, that configuration would have to be changed to incorporate a probe in the design.

The internal probe proposed for the F-15 raises no operational concerns. Although only engineering studies were performed, we were told that there were no reasons to believe that there would be any impact on the aircraft's maneuverability. However, since the space identified for the probe is also being viewed as a location for a modification intended to improve navigation and bombing accuracy, other available locations would have to be used for this planned F-15 enhancement.

Air Force Is Satisfied With Current Refueling System

The Air Force is accustomed to and satisfied with its fleet of boom-equipped tankers. It is also concerned about problems with probe/drogue systems. For these and other reasons, the Air Force has been unwilling to commit its resources to a different refueling system. These concerns must be considered when evaluating the probe/drogue system.

Having endured the changeover from the probe to the boom in the 1960s, 30 years later the Air Force would have to change once again if the refueling initiative is adopted. The current generation of Air Force pilots, however, is familiar and comfortable with the boom system. Adapting to a probe would require a fundamental shift from a passive role where the boom operator controls the refueling to an active role where the pilot alone is responsible for the hookup. Maintaining competency in both boom and probe refueling would also entail additional refueling training.

In addition, Air Force officials contend that the reliability and safety of the probe/drogue system is poor, while the highly dependable boom has served the fighter community well. As noted earlier, the design limitations

of the drogue adapter kit make it inherently unsafe and difficult to use. During Desert Shield, the Marine Corps air wing commander broke off all training with Air Force tankers after a kit accidentally damaged the nose of his aircraft. The Marine Corps relied on its KC-130 multipoint tankers during Desert Storm. In addition, the drogue mounted on the KC-10 fuselage has a design flaw that first emerged when the Air Force accepted delivery of the aircraft over 10 years ago. Air Mobility Command officials told us that numerous changes to the system have not corrected the problem and the number of incidents has remained constant over time. After the loss of a second naval aircraft in 1992, the Air Force initiated a test program to identify and correct the problem.

While these problems must be recognized, drogue safety and reliability should not be based solely on experience with the Air Force's boom drogue adapter kit or the drogue that is mounted on the KC-10 fuselage. Problems with these drogue systems are due to the equipment's well-recognized and long-standing design shortcomings. A more appropriate analogy would be the multipoint drogue pods on British tankers—similar to those being added to the 15 KC-10s—that have not experienced the problems of the fuselage mounted drogue.

Finally, with the bulk of the tanker force no longer committed to the nuclear deterrent mission, the Air Force believes that there are more than an adequate number of tankers to support fighters in conventional contingencies. Consequently, achieving greater operational efficiency in order to overcome a perceived tanker shortfall for conventional operations is no longer a pressing concern as it was during the cold war. On the other hand, the refueling initiative has potential cross-service benefits, including multipoint's ability to refuel fighters with fewer tankers and its compatibility with naval and U.S. allied aircraft.

Desert Storm Reinforced Original Multipoint Benefits

Desert Storm involved the most time-compressed and intensive air refueling operation in history. Immediately following the war, Central Command Air Force officials cited the limitations of single-point tankers and the benefits that would have accrued from multipoint. Subsequently, however, the air staff concluded that (1) multipoint would have been of marginal utility because time-compressed operations ended after the 3rd day of the 43-day war and (2) single-point tankers would have been preferred because of the reduced off-load capacity of multipoint tankers. Based on our extensive analyses as well as interviews with Central Command Air Force tanker personnel, we found that Desert Storm air

refueling operations confirmed multipoint's advantages as identified by RAND—efficiency, operational effectiveness, interoperability, safety, and flexibility—and also pointed out additional benefits during air space-constrained operations.

Surges of intense refueling activity—where multipoint shows the most benefit—became necessary for time-compressed missions by large packages of aircraft. These surges occurred during the first several days of the war, near the start of the ground campaign, and throughout the war for naval aircraft. Moreover, unpredictable refueling surges resulted from the dynamic nature of operational priorities—such as when Iraqi fighters tried to escape to Iran—and during weather fronts throughout the entire 43 days. Central Command Air Force officials noted that lack of multipoint severely limited operations because off-load points—not the quantity of fuel available—were the limiting factor during surges. To increase the number of off-load points, more single-point tanker missions were generated than were needed on the basis of actual fuel requirements. The British, who operated a fleet of 15 multipoint tankers during the conflict, noted that single-point tankers were not suitable for rapid refueling of multi-aircraft formations where timing over the target was often critical.⁷ The Marine Corps also found that its multipoint KC-130 tankers were valuable in reducing the amount of time required to refuel a formation of fighters.

In addition, multipoint tankers would have allowed the same or even a higher level of refueling with fewer aircraft and therefore with less crowding. Because of the finite amount of Saudi Arabian airspace and the large number of missions being supported each day, tanker refueling operations were frequently constrained by congestion and, hence, by flight safety considerations. For example, a last-minute, high-priority mission with a critical time window could only be accommodated by postponing another mission because there was no room in the sky for additional tankers. Moreover, a large number of near misses between tankers and other aircraft were reported.

Because about one-half of the coalition's combat aircraft required booms and the remaining half drogues, tankers had to be allocated among the two. Had the F-15 and F-16 been retrofitted with probes, about 75 percent of fixed-wing combat aircraft would have been standardized on the same refueling system. According to tanker planners, KC-135s with drogue

⁷British twin drogue tankers as well as Navy KA-6s were used to multiply the number of off-load points for naval strike packages. The KA-6 is a "tanker" version of an air-to-ground fighter and is used primarily in and around a carrier in the event landings are delayed by weather or other circumstances.

adapter kits were used to support the Navy. However, because of a shortage of fragile seals, the kits were left attached during the war, effectively eliminating the ability to shift those tankers to support Air Force assets. KC-10s, which could refuel either Air Force or naval aircraft on the same mission, were seldom allocated to support Navy strikes. In addition, due to the limited number of Air Force fighters equipped to suppress enemy air defenses, naval air defense suppression aircraft were often used in mission packages consisting primarily of Air Force aircraft. Thus, additional tankers had to be used to support such packages because even the KC-10 could not refuel both types of aircraft within the given time constraints.

The unpredictable nature of combat and the propensity for well thought out plans and schedules to go awry also suggest that multipoint would have been a useful capability during Desert Storm. For example, KC-10s were often paired with four F-15s on extended combat patrols designed to provide protection against Iraqi fighters. Typically, we were told, F-15s would fly in pairs from their assigned station to an orbiting tanker to refuel. Twin drogues would have reduced the F-15s' off-station time, increasing the ability to respond to threats that occur with little warning. Finally, although fighters were assigned to refuel from specific tankers, they frequently refueled from the nearest available tanker. One refueling unit reported that A-10s were often stacked up on a single tanker waiting for fuel. F-16 units also reported refueling queues on post-strike missions and cited the need for more off-load points.

Although single-point tankers met Desert Storm needs, they did not necessarily maximize operational flexibility and efficiency. Moreover, the disadvantages of single-point tankers may have been muted by unique circumstances. First, plentiful bases and fuel allowed planners to assemble a very large tanker force. Because of the sheer number of tankers available, operations planners could restrict the number of fighters scheduled to refuel from each tanker, helping to lengthen the refueling window but also contributing to large amounts of fuel being dumped and returned to base. A tanker cannot land with as much fuel as it can carry aloft and must use, off-load, or dump a certain amount of fuel. Second, air superiority was achieved early, giving the coalition greater latitude in spacing out strike packages so that sufficient tanker support could be provided. Third, an airspace refueling structure that enabled the coalition to achieve surprise on the first day was used throughout the conflict. The long refueling flight paths or tracks that carried fighters from their bases north toward the Iraqi border lengthened the time available to refuel strike

packages. Fourth, the long warning period between the August 1990 invasion of Kuwait and the January 17, 1991, coalition response provided time to locate and assemble sufficient boom drogue adapter kits; adequately train naval personnel who had very limited peacetime exposure to the kits; promulgate and practice an expedited technique for refueling from the boom; expose both tanker and fighter crews to refueling large formations of aircraft at night; and, meticulously develop a tanker schedule for the initial strike. Due to the above factors, Central Command Air Force officials acknowledged, and we agree, that Desert Storm is a point of reference but probably not a good analogy for future tanker operations.

KC-10 Multipoint Program Questionable Given Significant Downsizing of Initiative

Although there are several potential benefits associated with multipoint, retrofitting 15 KC-10s with twin off-load points may not be cost-effective if the Air Force does not plan to add probes to any of its fighter aircraft. Currently, the Air Force plans to sign a contract in August 1993 to complete the KC-10 multipoint program at an estimated cost of \$20 million to \$22 million. As noted earlier, only 1 of 15 planned multipoint KC-10s is currently in operational service.

Although the multipoint KC-10s are intended to support Navy fighters, the Air Force is proposing to address Navy air refueling requirements by adding multipoint to 75 KC-135 tankers. Further, the KC-10s are so heavily demanded by the Air Force that it is unlikely that the Navy will be able to take advantage of these tankers' multipoint capability. The KC-10 can be used for refueling, for moving cargo, or in both roles simultaneously. It can take off with nearly twice the amount of fuel as a modernized KC-135 or with more cargo than a C-141 airlifter. Due to problems with the aging C-141 fleet and delays in the acquisition of the C-17 airlifter, the Air Mobility Command is putting increased emphasis on the airlift role of KC-10s. Unlike the KC-135, the KC-10 is also air refuelable, making it a very efficient choice in supporting overseas deployments. Finally, while the Navy frequently requested the KC-10 because it prefers the fuselage mounted drogue system to the KC-135 adapter kit, during Desert Storm it was told that the KC-10 was assigned to higher priority Air Force missions.

Recommendations

To ensure that the capabilities of U.S. tanker and fighter forces are consistent with the different challenges of the post-cold war era and the increased emphasis on multiservice/multinational military operations, we recommend that the Secretary of Defense reassess the aerial refueling

initiative from a cross-service perspective with the primary goal of determining if probes should be added to Air Force fighters and how many multipoint tankers would be required to support Air Force and naval operations. The Program Analysis and Evaluation staff may be the best suited to perform such a study because it has both this perspective and the analytic resources required. To enable a more realistic comparison of the advantages and disadvantages of increased Air Force participation in the initiative, the reassessment should include interoperability, safety/reliability, fuel off-load rates, and trade-offs between internal and external probes for Air Force fighters. The reassessment should also contain a cost analysis that considers potential tanker retirements, including Marine Corps KC-130 assets.

We also recommend that the Secretary of Defense direct the Secretary of the Air Force to postpone awarding a contract to complete the KC-10 multipoint program until the reassessment of the aerial refueling initiative is completed. If the Secretary finds that the refueling initiative should be expanded by adding probes to some or all of the current and future Air Force fighter force, we recommend that the Secretary propose a roadmap to achieve the desired capabilities.

Matter for Congressional Consideration

Although the Department of Defense concurred with our draft report recommendation that a reassessment of the aerial refueling initiative was warranted, officials noted that the Department is reluctant to devote the resources need to conduct a new study. The potential benefits of the air refueling initiative—increased efficiency, standardization, and interoperability among Air Force, naval, and allied fighters during refueling operations—warrant such a reassessment. Accordingly, the Congress may wish to monitor the Department's written response required by 31 U.S.C. 720 to the recommendations in this final report. If the Department, in its response, is reluctant to fully reassess the initiative, Congress may wish to direct the Secretary of Defense to undertake the reassessment.

Agency Comments and Our Evaluation

The Department of Defense provided official oral comments on our draft report. Department officials did not disagree with our assessment that the Air Force understated the utility of multipoint and exaggerated the operational impediments to adding probes to Air Force fighters. Consequently, the Department concurred with our recommendation on the need to reassess the aerial refueling initiative.

Although the Department generally concurred with our report, officials expressed concern about the availability of resources needed to undertake a thorough reassessment of the aerial refueling initiative. They stated that the Department preferred not to initiate a new study and hoped that a nearly completed report titled "Tanker Requirements and Modernization-1993" would fulfill the need for such a reassessment. Officials acknowledged, however, that this modernization report does not address the (1) appropriateness of adding probes to current or future Air Force fighters, (2) number of multipoint tankers required to support an increased inventory of probe-equipped aircraft that would result from an Air Force decision to retrofit its fighters, (3) number of tankers that could be retired if air refueling were made more efficient by the addition of a multipoint capability, or (4) potential program costs. We continue to believe that an impartial and thorough reassessment of the aerial refueling initiative is required. As a result, we are suggesting that the Congress consider directing such a reassessment, if necessary. We also clarified the language of our original recommendation to emphasize that the reassessment should examine the issue of adding probes to Air Force fighters.

Department officials disagreed with our assessment that the KC-10 multipoint program may not be cost-effective or that the Navy may not be able to take advantage of that tanker's multipoint capability. Further, they stated that a postponement of the contract award could increase costs and further delay a needed operational capability. As a result, they did not concur with our recommendation to postpone awarding a contract to complete the KC-10 multipoint program until the above reassessment is completed.

Department officials offered no information to support their belief that the KC-10 program remains cost-effective. On the contrary, existing data shows that the program has been consistently over budget and behind schedule. The program was initiated in 1986 at an estimated cost of \$80 million with the goal of purchasing 40 sets of drogue pods. Currently, the program is estimated to cost about \$70 million but only envisions buying 15 sets of pods. Although flight testing of a modified aircraft began in 1989, 4 years later only one multipoint KC-10 is in operational service. In the interim, the Air Force initiated a second multipoint program for KC-135s to meet naval needs without considering the ongoing KC-10 program.

We continue to believe that the merits of the KC-10 multipoint program depend on the extent to which the Air Force modifies its fighters with probes. As was the case in Operation Desert Storm, the Navy may not obtain much benefit from the KC-10 because it is so heavily demanded by the Air Force. Thus, if no Air Force fighters are to be modified with probes and the Navy's needs will be met with multipoint KC-135s, a multipoint capability on the KC-10 may not have much utility. We agree that naval aircraft should be supported with a multipoint capability but believe that a short delay in the KC-10 multipoint program is warranted to ensure that it is a wise investment of resources.

Scope and Methodology

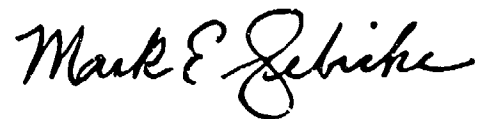
We assessed the status and evolution of the air refueling initiative by:

- Examining the theoretical basis for the program by reviewing and discussing the various multipoint studies with officials from RAND, Frontier Technology, the Air Force Studies and Analyses Agency, the Air Mobility Command, and the Office of the Deputy Chief of Staff for Plans and Operations, U.S. Air Force.
- Assessing the implications of multipoint for a real-world combat situation through extensive interviews with Central Command Air Force officials involved in directing and planning Desert Storm tanker operations, a review of pertinent after action reports, and development of a data base on consumed versus available fuel using tanker unit situation reports.
- Discussing the technical feasibility of probe/drogue modifications and other programmatic issues with F-15, F-16, F-22, KC-135, and KC-10 program managers at Air Force Headquarters, Washington, D.C.; the Air Force Materiel Command's Aeronautical Systems Center, Wright Patterson Air Force Base, Ohio, and; the Air Mobility Command, Scott Air Force Base, Illinois.
- Discussing technical issues related to retrofitting F-15 and F-16 fighters with engineers at McDonnell Douglas, St. Louis, Missouri, and General Dynamics, Fort Worth, Texas.

Our review was conducted between September 1992 and February 1993 in accordance with generally accepted government auditing standards.

We are sending copies of this report to other interested committees and Members of Congress; the Secretaries of Defense, the Air Force, and the Navy; and the Director of the Office of Management and Budget. We will also make copies available to other parties upon request.

Please contact me at (202) 512-5140 if you or your staff have any questions concerning this report. The major contributors to this report were Julia Denman, Assistant Director; Walter Ochinko, Evaluator-in-Charge; and Trisha Kurtz, Evaluator.



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Director
Military Operations and Capabilities Issues