IMPROVING AFRICAN FUEL AVAILABILITY IN SUPPORT OF HUMANITARIAN RELIEF OPERATIONS

Graduate Research Paper

Steven C. Dye, Major, USAF

AFIT/GMO/LAC/99E-3

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GRADUATE RESEARCH PAPER

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Abstract

Airlift operations into Africa are fuel intensive due to the great distance from the U.S. to the Africa as well as size of Africa itself. Poor fuel infrastructure in Africa makes airlift operations increasingly difficult. United States European Command requested this study to examine methods for meeting the fuel requirement for a humanitarian relief operation in Africa.

The three methods include air refueling as was done in Operation SUPPORT HOPE, a new initiative from United States European Command, and Offshore Petroleum Distribution System. Operation SUPPORT HOPE, humanitarian relief of Rwandan refugees, is examined for two reasons. First, it is the model for the expected airlift for just such an operation. Second, Operation SUPPORT HOPE was considered a success, so the methods may be the best possible solution. United States European Command's initiative is to either store fuel or contract for guaranteed fuel delivery at several locations in Africa. The final method examined is using the Offshore Petroleum Distribution System (OPDS). The OPDS is a specially equipped tanker ship capable of mooring four miles from shore and pumping aircraft fuel to the shore. The paper examines each option in terms of operational considerations and cost.

The paper concludes with the finding that USEUCOM's initiative would be worthwhile in one or more of three locations, Abidjan, Ivory Coast; Douala, Cameroon; and Libreville, Gabon. Air refueling is the best solution for short notice relief operations elsewhere. OPDS is the best solution in remote locations where neither commercial supply nor air refueling can meet the requirement.

IMPROVING AFRICAN FUEL AVAILABILITY IN SUPPORT OF HUMANITARIAN RELIEF OPERATIONS

I. Problem Statement

Introduction

In support of African regional crises, we have increasingly deployed forces to or evacuated personnel from locations on the African Continent. Because Africa faces numerous challenges related to population growth, political and social instability, we can expect Africa to remain a hot spot for the foreseeable future. Most of the African nations are fledgling nations having gained their independence since the 1960s and therefore, many are still unstable and will remain so for the foreseeable future. As the remaining superpower, the U.S. will have to stay engaged in Africa to ensure our national objectives.

Historically, our military operations into Africa have been non-combatant evacuation operations (NEO) and humanitarian relief operations (HUMRO). A recent example of a NEO operation occurred in 1999 when we went into Brazzaville to evacuate Americans and other foreign nationals from the Democratic Republic of Congo due to their civil war. Operation SUPPORT HOPE in 1994 was a HUMRO operation in which we flew relief supplies and water purification equipment from the U.S. and Europe to Rwanda. This paper concentrates on the HUMRO operation, but fuel considerations are equally applicable to both types of operations.

Airlift operations into Africa are extremely difficult for two reasons related to long distances. First, there is significant distance between U.S. soil and the African

Continent. For example, the distance from the Charleston AFB, South Carolina, our nearest AMC base, to Dakar, Senegal, the nearest frequented Africa location, is 3550 nautical miles. A C-17 with 100,000 pounds of cargo (an appropriate load for a C-17) can just barely fly that distance if the route is direct, the winds are nearly calm, and proper flight altitudes are available. For future reference, an *empty* C-17 can fly approximately 4300 nautical miles with zero wind and an alternate landing location within an hour of the planned destination. With a load of 100,000 pounds of cargo, the distance is shortened to approximately 3600 nautical miles. Second, the distances within the African continent are great. Africa is 4350 nautical miles from the North to the South

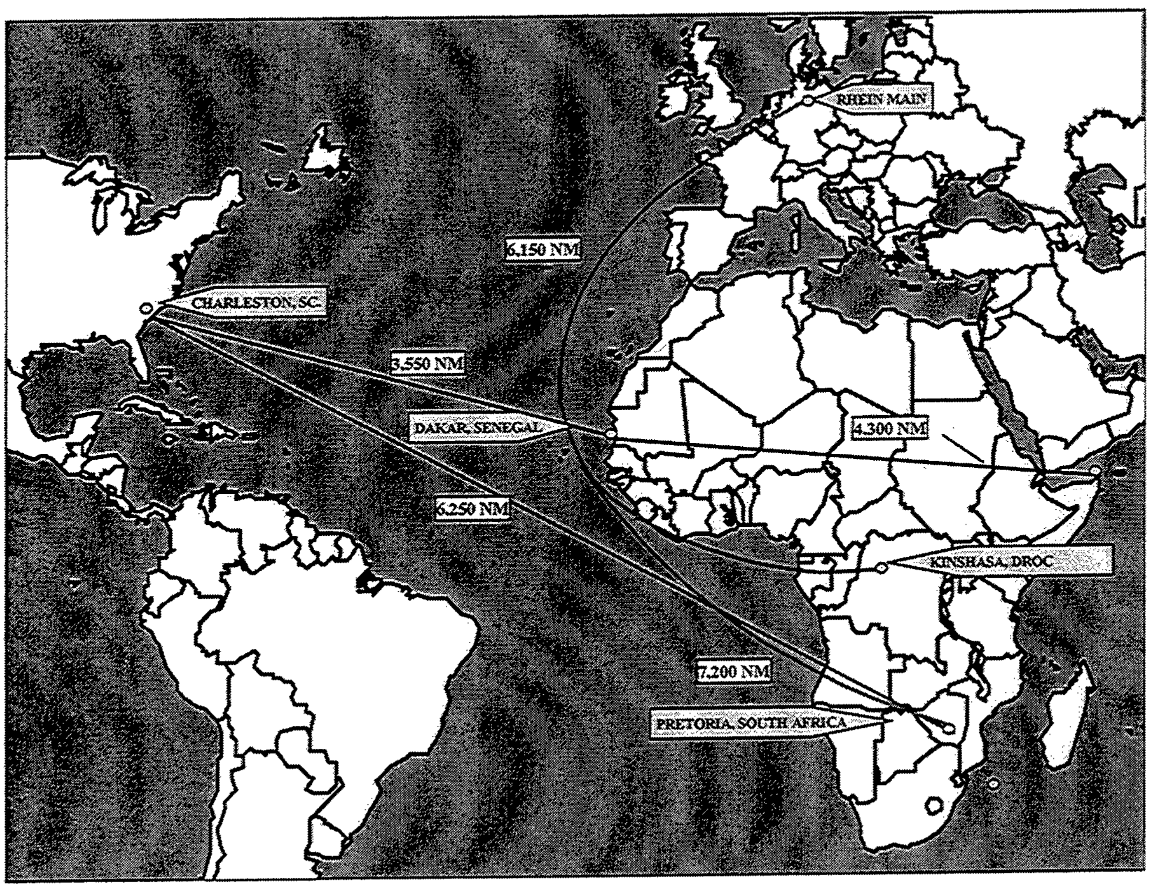

Figure 1. Great Distances to Africa (USEUCOM JPO, 1999)

and 3900 nautical miles from East to West at its widest point. A C-17 with 100,000 pounds of cargo cannot fly either distance without stopping for fuel or air refueling (FalconView3©). Given the great distances involved, how then did we accomplish Operations SUPPORT HOPE, the Humanitarian Relief Operation (HURMO) in 1994?

During Operation SUPPORT HOPE in 1994, we used KC-135 and KC-10 tanker aircraft extensively to air refuel almost every strategic airlift aircraft flying into Africa. We even used KC-10 and Marine Corps KC-130 aircraft to transport fuel between ground locations when fuel became the limiting factor at Entebbe, Uganda (Peck, 1999). There is not enough aircraft fuel available at any one location in Africa or even at the combination of often used locations to support a HUMRO operation like Operation SUPPORT HOPE without extensive use of air refueling. Although the very reason we have air refueling aircraft is to enable worldwide operations, operational costs rapidly multiply when we have to deploy and fly air refueling aircraft. If we expect to regularly operate in Africa, perhaps we should search for a less expensive and less operationally taxing method of meeting our national objectives in Africa.

United States European Command (USEUCOM), the geographic combatant command for Africa as well as Europe, requested this study to explore possibilities for alleviating the fuel shortfall in Africa. USEUCOM has a tentative Joint Staff approval to purchase fuel guarantees or store fuel in Africa (Mattox, 1999). USEUCOM must determine the validity of purchasing guarantees or storing fuel in Africa and if so, how much fuel to store and where that fuel should be stored.

Research Question

The purpose of this Graduate Research Project (GRP) is to examine three methods for meeting the fuel requirement for a HUMRO in Africa. We will use Operation SUPPORT HOPE as the model for future HUMROs into Africa because it was a recent operation and because it was representative of the same kind of problems we should expect in Africa for the foreseeable future.

Investigative Questions

The GRP focuses on three options to meet the fuel shortfall. Given the success of Operation SUPPORT HOPE, first we examine Operation SUPPORT HOPE's use of KC-135 and KC-10 tanker aircraft to meet the shortfall. Then we examine an option for either purchasing and storing fuel or contracting for guaranteed fuel availability at locations in Africa. This option requires money budgeted in anticipation of future operations unlike the use of tanker aircraft. The third and final option we explore involves using the Navy's Offshore Petroleum Distribution System (OPDS) to deliver fuel to coastal airports when and where needed. OPDS is a sealift tanker with special equipment allowing it to anchor off the coast and pipe fuel to the shore. Finally, we compare and contrast the three options and recommend the best solution for USEUCOM.

Scope and Limitations

This paper focuses on bulk fuel availability at locations surveyed by a USEUCOM and Defense Energy Supply Center (DESC) team in January 1998. Those locations include Dakar, Senegal; Abidjan, Ivory Coast; Cotonou, Benin, Libreville, Gabon; Douala and Yaounde, Cameroon; and Entebbe, Uganda. Although there are hundreds of airfields in Africa, most airfields are too short for strategic aircraft, are in countries with which we have no diplomatic ties, or have infrastructure or support shortfalls including limited fuel and limited ramp space. The airfields listed above meet many of the needs for strategic airlift. Cape Town, South Africa, Cairo, Egypt and Mombassa and Nairobi, Kenya will also be considered as they are familiar destinations for military airlift and have known fuel capabilities.

Monetary costs and operational limitations are the basis for comparison. Fuels are addressed in gallons and distances are addressed in nautical miles for consistency sake, unless specifically indicated otherwise.

Assumptions

DESC will attempt to purchase bulk fuel storage or guarantee contracts as requested by USEUCOM and previously approved by the Joint Staff. All aircraft are assumed capable of using Jet A1 fuel without Fuel System Icing Inhibitor (FSII) added. Most aircraft can and do currently fly all missions into Africa using Jet A1 fuel without FSII as an alternate fuel. KC-135 aircraft are a notable exception, but DESC is addressing the anti-ice limitation and may shortly have a method to add FSII at the skin of the aircraft. This paper does not address anti-ice limitations and therefore, anti-ice limitations are assumed not to degrade mission accomplishment.

All fuel and distance computations are done using FalconView3© version 3.01 software with C-17 and C-5 modules added. Although reasonably accurate for the purposes of this macro-level study, actual fuel quantities burned will differ according to winds, route of flight, alternates used, and cargo carried. None of the fuel computations in this paper should be used for actual flight planning. Additionally, all routes of flight are direct from point of takeoff to point of landing with a reasonable divert fuel. Overflight and diplomatic clearance restrictions posed by nations along the route of flight will significantly increase fuel requirements, reduce the numbers of sorties that can be supported by a given fuel store, and make some destinations unreachable due to increased flight distances.

Review of GRP Organization

This paper begins with a description of Operation SUPPORT HOPE and how the U.S. met the HUMRO airlift requirements using in-place African fuel capabilities as well as extensive KC-135 and KC-10 tanker support. Chapter III examines the issue of contracting for storage of fuel or guaranteed fuel availability at some of the eight earlier named locations in Africa. Chapter IV addresses the potential for OPDS to solve the fuel shortfall. Chapter V compares and contrasts the costs, strengths, and weaknesses of each option, addresses areas for further inquiry, and concludes with recommendations.

II. Operation SUPPORT HOPE

Background

On 6 April 1994, the presidents of Burundi and Rwanda, two small neighboring states in west central Africa, were killed when their plane was struck by a rocket and crashed in Kigali, the capital of Rwanda. The two presidents had been working to end the long-standing and bloody conflict between members of the two ethnic groups, the Hutus and Tutsis (Reese, 1995:8). This sparked immediate violence in Kigali as the majority Hutus turned on the minority Tutsis. The violence in Kigali precipitated a series of events that, by the middle of July had resulted in the death of as many as a half million people, mostly Tutsis, and had forced another two million people to become refugees (Starr, 1995:ii).

Most of the refugees moved westward out of Rwanda, just over the border into Goma, Zaire, which is now called the Democratic Republic of Congo (see Figure 2). A smaller number of refugees moved southwest to Bukavu, Zaire. The USAF participation began in early May under the name Operation PROVIDE ASSISTANCE. Between 11 May and 22 July, the Tactical Airlift Control Center (TACC) directed 92 missions into Africa carrying 2,516 tons of relief supplies ("AMC Airlifts Aide to Rwanda," 1994:18). However, Operation PROVIDE ASSISTANCE was but a small part of the total U.S. effort.

News broadcasts by the middle of July documented horrendous conditions in Goma. The press reported as many as 3,000 persons dying per day and showed horrific pictures of mass burials. On 22 July, the President ordered Operation SUPPORT HOPE with the goal to stop the dying (AMC/HO, 1994:193).

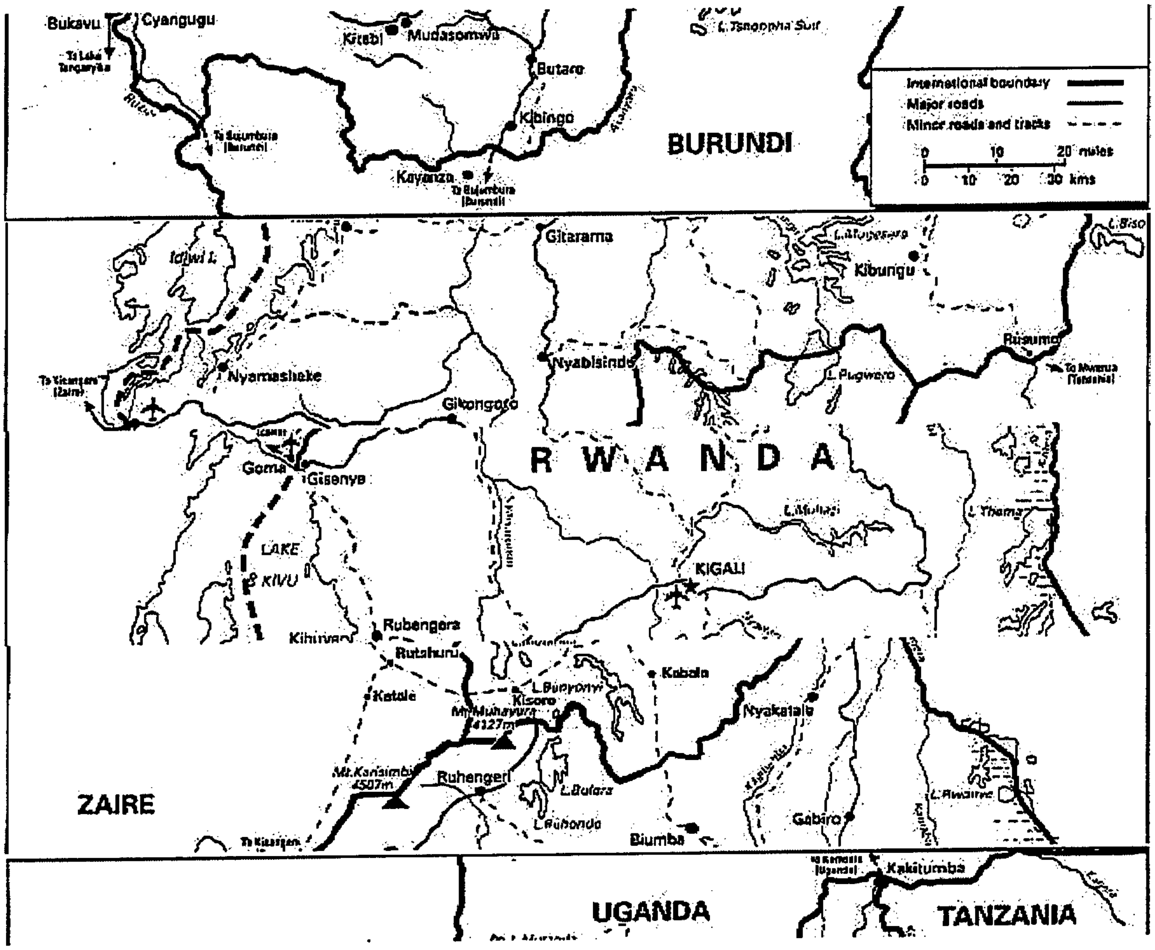

Figure 2. Rwanda (Connaughton, 1996:3)

U.S. Intentions

U.S. actions in Operation SUPPORT HOPE were shaped by recent events in Mogadishu, Somalia. During peacekeeping operations in Mogadishu, U.S. Army Rangers were killed and one soldier's corpse was dragged through the streets. The press televised the dragging in the U.S. and Americans were outraged. This drove President Clinton to limit our actions in the Rwandan crisis to Humanitarian Relief Operations (HUMRO), far less dangerous than the peacekeeping operation in Somalia (Connaughton, 1996:56).

The Joint Task Force Commander directed five phases for Operation SUPPORT HOPE. The five phases were to stop the dying, return the refugees to Rwanda, support stability in Rwanda, turnover the operation to UN agencies, and finally redeploy the forces (Schroeder, 1994:B3). A HUMRO attempts to relieve human suffering by providing relief supplies including food, water, and shelter and distributing the supplies to the refugees. Because of the location of the crisis, Operation SUPPORT HOPE would prove to be a difficult operation. Moving cargo into the middle of Africa is not an easy task to perform, even for the U.S. military.

Overview of Operations

The majority of U.S. relief supplies were flown from the designated collection point at Rhein Main AB, Germany to Entebbe, Uganda. Strategic airlift sorties from Europe required air refueling over the Mediterranean Sea to complete the leg into any of the African destinations shown in Figure 3. However, a notable exception was two C-5 sorties, which flew 22 hours and 14 minutes with three air refuelings directly from Travis AFB, California to Goma, Zaire with a water purification unit (AMC TACC/XOCB, 1994). The airfield at Goma nearest the refugees could not be used as the hub of operations because the runway was in poor condition and was deteriorating with each landing. Additionally, Goma had limited ramp space especially for large aircraft, and absolutely no fuel for U.S. aircraft. The planners chose the Entebbe airfield as the primary hub for strategic air traffic (C-141 and C-5 sorties) thus receiving 84 percent of the inbound cargo. Nairobi and Mombassa, Kenya were designated secondary hubs, but received little of the inbound cargo. After landing at Entebbe, relief supplies were transloaded into C-130s for the trip to Goma or later Bukavu, Zaire and Kigali, Rwanda (Star, 1995:20). Eventually overland trucks supplanted C-130s and were used to move relief supplies from Entebbe to the location needed (Peck, 1999). Entebbe became a busy airfield for the duration of Operation SUPPORT HOPE.

Mission totals for Operation SUPPORT HOPE aircraft through Entebbe were impressive. A total of 71 C-5 missions, 196 C-141 missions, and 701 C-130 missions transited Entebbe between 24 Jul to 30 Aug 1994 (Starr, 1995:55-60). To understand the fuel requirement for such an airlift, one should begin with the aircraft fuel capacities. Internal fuel capacities for a C-5, a C-141 and a C-130 are 51,470, 22,560, and 6,470 gallons respectively. The C-5 and C-141 missions arriving at Entebbe would have landed with just enough fuel to divert to Nairobi or Mombassa, or 3,680 or 2,210 gallons respectively. The aircraft would consume a full fuel load on the return leg to Europe, or an additional 47,790 or 19,850 gallons respectively. Multiplying the figures for the strategic aircraft results in a fuel requirement at Entebbe for 7,284,560 gallons of fuel. A C-130 mission flying an out and back mission to Goma, would burn approximately 1,470 gallons, or a total of 1,030,470 gallons for the 38 day period (FalconView3©). The grand total for all U.S. aircraft over the period theoretically could be as high as 8,315,030 gallons. Today the storage capacity at Entebbe is 591,839 gallons and the daily issue capability is 79,264 gallons per day (Grant, 1998:7).

Daily resupply figures are not available for the time during Operation SUPPORT HOPE, but Shell Corporation did increase the flow into Entebbe during the operation. Shell set aside a 300,000 gallon fuel tank for U.S. usage (Peck, 1999). If Entebbe began the 38 day period with 591,839 gallons of fuel, Shell would have to refill the fuel storage system 13 times and triple their current issue capability. Fuel limitations quickly shaped the dynamics of Operation SUPPORT HOPE.

A number of creative actions improved the overall fuel situation at Entebbe. Air refueling procedures over the Mediterranean were changed to improve the amount of fuel onboard aircraft arriving to Entebbe, KC-10 tanker aircraft flew continuously overhead Goma ready to air refuel, and KC-10 and KC-130 tankers flew fuel to Entebbe. Each of these procedures reduced fuel requirements at Entebbe, but they were costly and they complicated the delivery of relief supplies.

Air Refueling over the Mediterranean

All aircraft departing Europe required air refueling to complete the flight into Central Africa. KC-135 aircraft stationed at RAF Mildenhall, UK met the airlift aircraft and passed sufficient fuel to complete the mission to Central Africa (AMC TACC/XOOX, 1994B:5). The shortage of fuel in Africa modified the goal of air refuelings over the Mediterranean. Aircrew Handout Number Three, published on the 11th of August, was devoted to increasing the amount of fuel European originating sorties carried into Africa so as to minimize in Africa refueling requirements. Strategic aircraft were directed to take as much fuel as possible from their departure base. The new air refueling procedure was for airlift aircraft to take on as much fuel as allowed by aircraft gross weight limitations during the air refueling (AMC TACC/XOOX, 1994C:1).

Carrying extra fuel is expensive as well as wasteful. As a rule of thumb, a C-141 burns three percent of the extra fuel it carries every hour of flight. Aircraft air refueling over the Mediterranean five hours before landing at Entebbe would burn 15 percent of that extra fuel en route, leaving 85 percent of the extra fuel carried available for the subsequent sortie. Put another way, fuel carried over a five-hour leg for later use is 17 percent more expensive than similarly priced fuel at the destination.

If one conservatively estimates the number of aircraft that carried extra fuel into Africa and then multiply the additional costs, we can get a gross estimate of the costs due to taking off with extra fuel and receiving extra fuel from the tankers. From the 12th to the 30th of August, 18 C-5s and 84 C-141s transited Entebbe. One can conservatively estimate that the C-5s and C-141s carried an additional 7,000 and 4,000 gallons, respectively. The total carried was 462,000 gallons of which 69,300 gallons, or almost three C-141 fuel loads, were burned in the process of carrying the fuel. At today's DESC fuel rate of 81 cents per gallon, the cost of wasted fuel is $56,133 (Wilt, 1999).

KC-10 Tanker Operations at Harare, Zimbabwe

All aircraft transiting Goma had arrival slot times, which often slipped or changed during the eight-hour flight time from Europe to Goma. On the 2nd of August, the TACC modified the SUPPORT HOPE Aircrew Brochure with Aircrew Handout Number One, setting up a KC-10 air-refueling pattern over Goma. Each day, three of the four KC-10s stationed at Harare, Zimbabwe would fly just northeast of overhead Goma and orbit for six and one third hours ready to provide 4,500 gallons of fuel to any AMC aircraft in need. The three KC-10s flew sequentially thereby providing a 19-hour window of coverage in the refueling pattern (AMC TACC/XOOX, 1994B:1). This ensured inbound aircraft could loiter, if necessary, to wait for a landing slot time in spite of congestion on the airfield (AMC /HO, 1994:195). By 15 August, when the KC-10s redeployed, KC-10s from Harare had passed 96,000 gallons of fuel on air refueling missions (Starr, 1995:13).

To calculate the operational cost of the KC-10 air refueling cap over Goma one can multiply the number of hours flown by the AMC Special Airlift Rate of $7,858 (AMC/QMIF, 1998). The three KC-10s flew a total of 25 hours each day, when one adds the in-transit times and therefore logged 150 hours over the six days from the 2nd through the 7th of August. A conservative estimate of the flying cost to keep the 19-hour window of KC-10 coverage open is $1,178,700. Unfortunately, the total cost for operating four KC-10s at Harare is far higher than just the cost of flying. Total costs are not available, but would have included TDY payments for maintenance and support personnel.

Moving Fuel to Entebbe by Aircraft

The fuel storage and resupply capabilities at Entebbe fell short of what was required for the operation. At the same time, strategic aircraft were prevented from flying into Goma due to ramp space limitations and runway degradation. The reduced air refueling requirement in the orbit over Goma freed up some of the KC-10s at Harare. The KC-10s at Harare and the Marine KC-130s deployed to Mombassa began to move fuel by air to Entebbe.

On 29 and 30 July, KC-10s tested fuel offload operations at Entebbe. On 31 July fuel specialists began defueling KC-10s at Entebbe. By the 15th of August, KC-10s delivered more than 304,000 gallons of fuel into the Entebbe underground storage tanks (Star, 1995:13). Flying round trip from Harare to Entebbe takes approximately five hours (FalconView3©). Due to the fuel burned en route and the required alternate fuel, each

KC-10 could deliver approximately 30,000 gallons of fuel each trip to Entebbe. Therefore it took at least 50 hours of flying at $7,858 each, or $785,800 total, to deliver the fuel by air from Harare to Entebbe. Not accounted for in this paper was a processing fee by Shell to receive and then redeliver the fuel to U.S. aircraft at Entebbe.

Harare had fuel limitations of its own. According to the mission commander, three of the KC-10 missions had to fly 217 miles to the northwest to Lusaka International, Zambia to get fuel to complete their missions. Additionally, when the last KC-10 tried to leave Harare, Harare did not have enough fuel on hand to fill the KC-10. Conveniently, there was a KC-10 at Gabrone, Botswana in need of brake parts. The last KC-10 departed Harare with just enough fuel to take the brake parts to Gaborne, 500 miles to the south of Harare. At Gaborne the KC-10 received fuel for the return flight to the U.S. (Hurd, 1999).

Total Costs

When one adds the costs of carrying extra fuel from KC-135 tankers over the Mediterranean, KC-10 operations overhead Goma, and KC-10 ground delivery to Entebbe, the total comes to a surprising $2,020,633 over and above the cost for the fuel itself. For that sum the U.S. delivered to Entebbe 862,000 gallons of fuel. The cost of the fuel plus the delivery cost results in an effective price of$3.15 per gallon, or almost four times the normal purchase price.

Conclusions

On 26 September 1994, the Joint Task Force Commander declared Operation SUPPORT HOPE "mission complete"and ordered redeployment of the troops. The Non-Governmental Organizations had taken over the refugee supply efforts and AF airlift was no longer needed (Schroeder, 1994:B18). The dying was reduced from 5,000 per day to less than 250 per day (Schroeder, 1994:B17). By any measure Joint Task Force had achieved its primary goal despite fuel limitations in Africa.

Approximately one tenth of the fuel burned by the U.S. aircraft transiting Entebbe was passed by air refueling or transported by air refueling tanker to the ground system into Entebbe. Our tanker assets gave us the capability to meet the airlift requirements for the HUMRO mission as severe at Operation SUPPORT HOPE, but at a significant cost. Surprisingly, the Joint Task Force Commander mentioned the limitation of aircraft fuel at the various locations in only *one* status report to his commander. The omission may have been because Operation SUPPORT HOPE confirmed our expectation of poor fuel infrastructure in Africa (Peck, 1999).

The extensive use of tanker aircraft takes those much-needed assets away from other operations, such as the current war in Serbia. The extensive use of KC-10s is especially painful, because the U.S. loses not only its air refueling capability, but the KC-10's airlift capability as well. We might not have the tanker assets available to do an operation such as SUPPORT HOPE as well as the current war in Serbia. In the case of a HUMRO, the U.S. could choose not to get involved. However, in a non-combatant evacuation operation (NEO), the U.S. would have no choice but to attempt both the war and the NEO simultaneously. One of the two operations may have the resources necessary for success.

III. USEUCOM Initiative

Background

The Commander in Chief (CINC) of USEUCOM outlined eleven objectives in his "Strategy of Readiness and Engagement." Objective nine is to "Provide Prompt Response to Humanitarian Crisis." The CINC recognized that the scale and nature of the crisis as well as the urgency of the need, particularly in sub-Saharan Africa, require military capabilities to prevent widespread loss of life (United States European Command, 1998:21). The CINC thought this task critical enough to make it one of only eleven objectives for his command. Operation SUPPORT HOPE emphasized the shortfall of fuel in Africa for responding to humanitarian crises. The USEUCOM Joint Petroleum Office (JPO) has been devising a smart way to overcome the shortfall (Stanley, 18 Feb 99).

Concept

The African continent is large. It spans 4,350 miles from North to South and 3,900 miles from East to West at the widest point. Even our strategic aircraft cannot cover either distance without refueling. A humanitarian crisis could occur anywhere in the continent, so the concept has to allow cargo aircraft to land at any point on the continent. Additionally, the arriving aircraft cannot expect to have fuel available at the crisis location, so the aircraft must be able to depart the crisis area without refueling. To make matters more difficult, the airfields nearest the points of crisis often are either too short or unstressed to support larger, strategic aircraft. C-130 Hercules aircraft offer the ability to land at short, unprepared airfields, but are range limited. USEUCOM, through

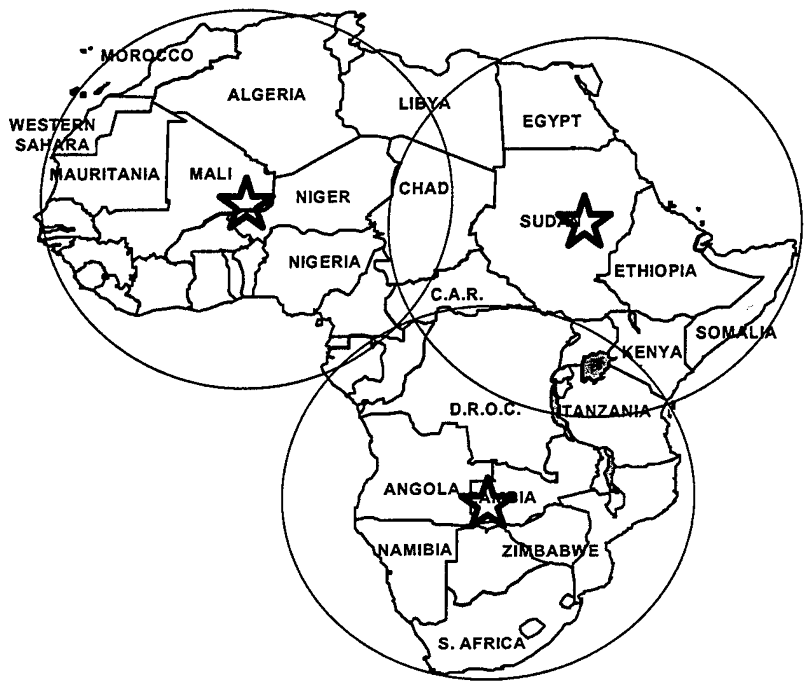

Figure 3. Optimum ISB Locations

USAFE, has C-130s under its command and is comfortable with building a plan around using C-130 aircraft and has thus, developed a concept around their use.

The concept calls for designating Intermediate Staging Bases (ISB). Ideally, each ISB would have both fuel stock and resupply capabilities necessary to support a NEO or HUMRO mission. Strategic aircraft would fly into and out of the ISBs. At the ISBs the cargo would be transloaded on to C-130s. C-130s would fly the cargo to the airfield where needed and then return to the ISB *without* refueling. Therefore the out and back range of a C-130 dictates a circular area centered on the ISB that can be serviced from that ISB (Wilt, 1999).

The out and back range for a C-130 with 15,000 pounds of cargo is approximately 1300 nautical miles. This distance is calculated using zero wind and direct routing. It also allows enough fuel for the aircraft to divert for any reason to an airfield up to 300 miles away as well as hold or orbit for the regulation-required 45 minutes. 1300 miles is the maximum distance one can expect for C-130s to fly out and back (FalconView3©).

In a perfect world, we would select two ISBs in North Africa and a third ISB in South Africa, all approximately 1300 miles from the coastline (see Figure 3). With three ISBs so placed, we could have C-130 coverage for the entire continent. However, due to diplomatic and cost reasons, we are limited to using existing airfields. Redundancy or overlapping coverage is another concern. When a humanitarian crisis kicks off, we should not allow our plans to hinge on access to the single location. Selecting more than three locations affords USEUCOM overlap of coverage areas and redundancy for operations that might require more than the planned for amounts of fuel.

Current Fuel in Africa

Figure 4 shows the location of all African airfields where DESC has into-plane contracts for refueling US aircraft. There are numerous locations where U.S. aircraft can be fueled, but few locations have a large quantity in storage or are able accommodate surge situations. The optimum locations according to Figure 3 fall in

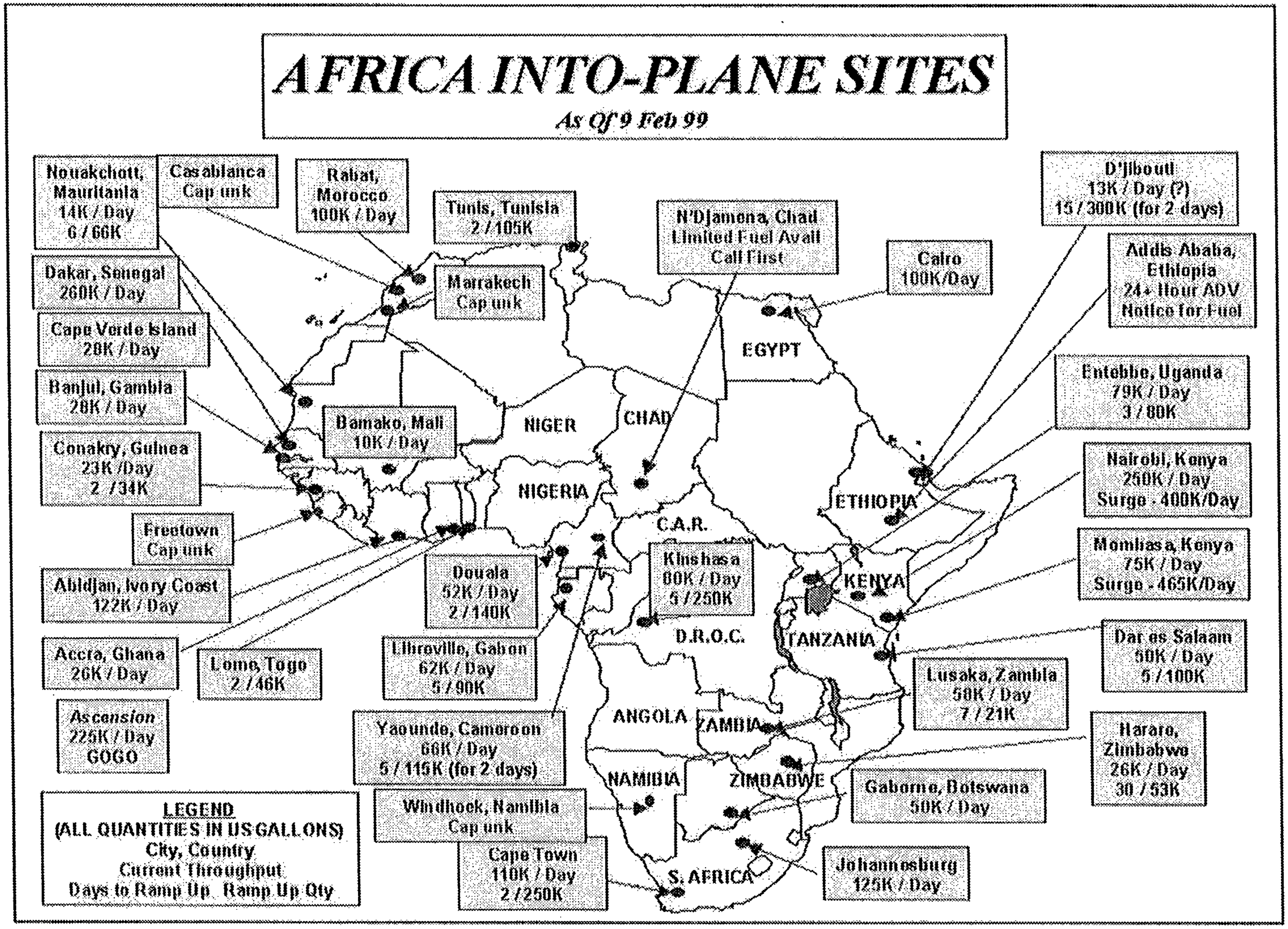

Figure 4. African Into-Plane Sites (USEUCOM Joint Petroleum Office: 1999)

Sudan, Niger/Mali, and Zambia. We do not have an into-plane contract with Sudan. Mali offers only one location, Bamako, which has but 10,000 GPD capability, and is a few hundred miles from the optimum location. The third location in Zambia is near Lusaka offers 58,000 gallons storage and 21,000 GPD issue capability. None of those locations is capable of matching the estimated amount of fuel necessary for a NEO or HUMRO.

The fuel amounts listed in Figure 5 are best case/full fuel tank figures. When a crisis kicks off, commercial airlines, Non-governmental Organizations' charter flights, and other nations' militaries all compete for the same fuel. There is no guarantee that any of the fuel in the Into-Plane Figure will be in the tanks or available for U.S. usage.

Services Determined Fuel Requirement

USEUCOM JPO asked the services to determine the amount of fuel required supporting NEO or HUMRO operations in sub-Saharan Africa. At the time of this writing, the worst case expected fuel requirement was 242,000 gallons per day (GPD). 242,000 GPD seems in line with the experience from Operation SUPPORT HOPE. Because ISBs may need time to ramp up fuel deliveries to the 242,000 GPD requirement, the JPO office recommends storing 10 days fuel reserve or 2.42 million gallons at the ISBs (Mattox, 1999).

High Capacity Location Alternatives

There are four locations that meet the 242,000 GPD requirement. These locations include Dakar, Senegal at 260,000 GPD, Nairobi, Kenya at 250,000 GPD, surge to

400,000 GPD, Mombassa, Kenya at surge of 465,000 GPD, and Cape Town, South Africa at 250,000 GPD. Let's look at each alternative separately.

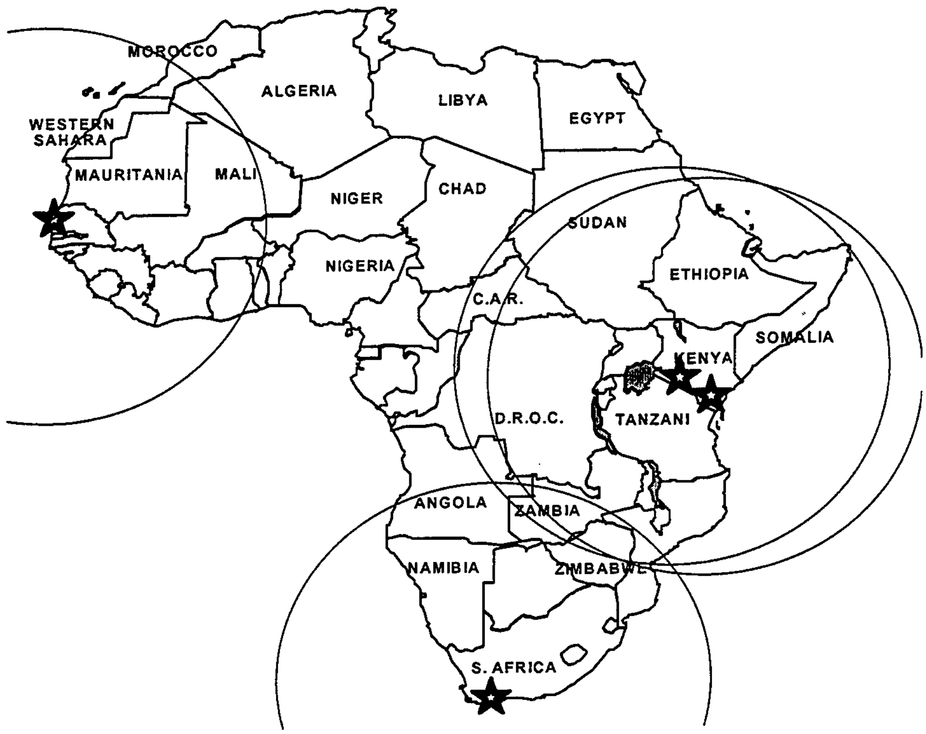

Figure 5. Mombassa, Nairobi, Dakar and Cape Town ISB Coverage

Dakar is transited regularly by AMC flights into Africa and was used during the Presidential visit to Africa in March 1998. Current fuel capacity at Dakar is 826,990 gallons with a resupply of 260,000 GPD. As Dakar is the only African airfield reachable from the CONUS, it is a necessary choice as an ISB. Dakar's capacity is one third the desired 2.42 million gallons. However, the operators plan to construct a new storage tank by the year 2000 (Grant, 1998:2).

Nairobi and Mombassa, Kenya are modern airfields with excellent resupply capabilities. Nairobi has an unmatched capacity of 14.3 million gallons and throughput of 250,000 GPD, exceeding the requirement even before considering the surge capability of 400,000 GPD. Mombassa has a capacity of 1.7 million gallons and an unmatched surge capability at 465,000 GPD (Mattox, 1999). Nairobi and Mombassa offer some redundancy for Central Western Africa. Unfortunately, both would be subject to the same diplomatic constraints, taking away some of their redundancy usefulness. 282 miles separate Nairobi and Mombassa, so they would require separate Tanker Airlift Control Element manpower and equipment packages.

Cape Town, South Africa can surge to 250,000 GPD in two days, but has the distinction of being the southernmost into-plane contract location on the continent. Being so far south is significant because a crisis in Namibia, for example, would require strategic airlifters to overfly the crisis by several hundred miles to transload their cargo to the C-130s which would then backtrack to Namibia. While not an efficient choice for the U.S., Cape Town offers redundancy when there are no better options. Using only those locations leaves much of the continent uncovered as shown in Figure 5.

Lesser Capacity Options

This paper will examine seven lesser capacity possible ISBs. These include Abidjan, Ivory Coast; Cotonou, Benin; Libreville, Gabon; Douala and Younde, Cameroon; Entebbe, Uganda; and Cairo, Egypt. A Defense Energy Supply Center (DESC) team visited all these locations except Cairo in 1998. Their purpose was to assess fuel, food, and water infrastructure for supporting USEUCOM operations (Grant, 1998:1). This paper will discuss each airfield separately in the order above.

Abidjan, Ivory Coast is 982 miles southeast of Dakar and overlays coverage for part of Niger, Nigeria, Cameroon and part of Gabon. Abidjan has a total storage capacity of 701,488 gallons. However, Abidjan can issue only 209,257 GPD and daily commercial aircraft issues include all but 87,120 GPD of that. Interestingly, the into-plane information presented earlier shows a current throughput capability of only 122,000 GPD, which is 87,257 GPD short of the figure found by the DESC team's trip report. Both capacity and throughput are far short of the 2.42 million gallons and 242,000 GPD desired under the USEUCOM concept.

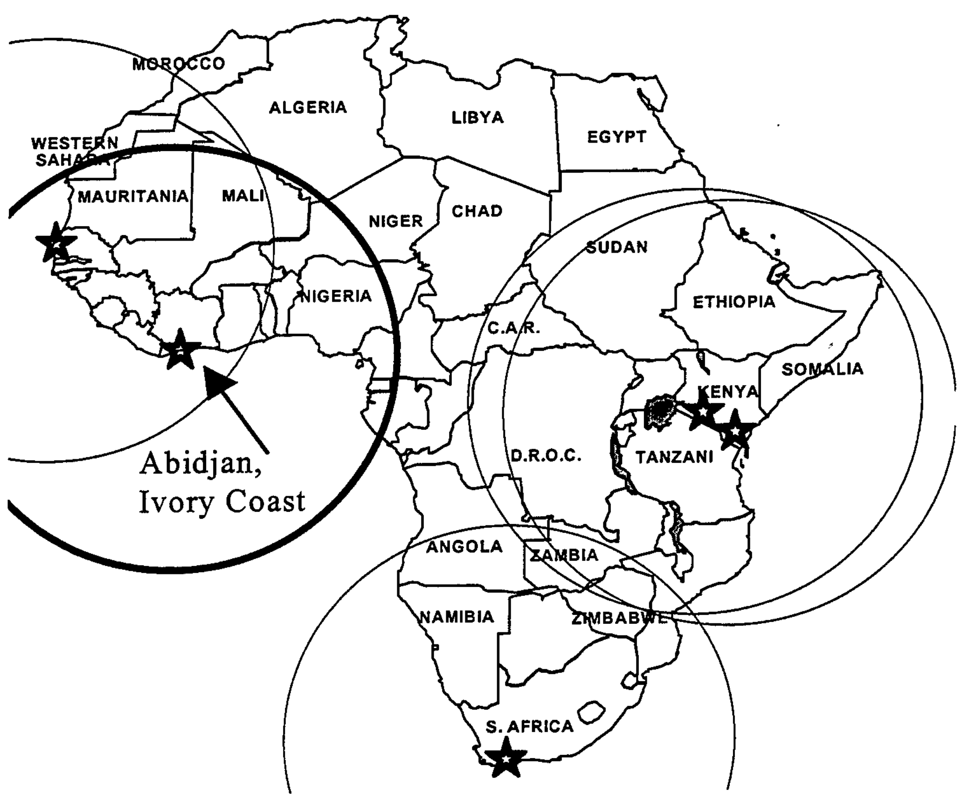

Figure 6. Adding Abidjan ISB Coverage

Cotonou, Benin is 383 miles east of Abidjan and does not have an into-plane contract. Cotonou has only a 214,013 gallon storage capacity and can only issue 79,264 GPD. Furthermore, the fuel operators at the airfield may soon privatize, leaving in peril any agreements we may have made before the privatization. The airfield has a small ramp, parking only four C-130s and three helicopters at a time, short of the requirements for a strategic hub (Grant, 1998:4). This paper will not consider Cotonou further.

Libreville, the capital of Gabon, is on the West Coast, approximately halfway between Dakar and Cape Town at similar latitude with Nairobi, Kenya. Libreville has

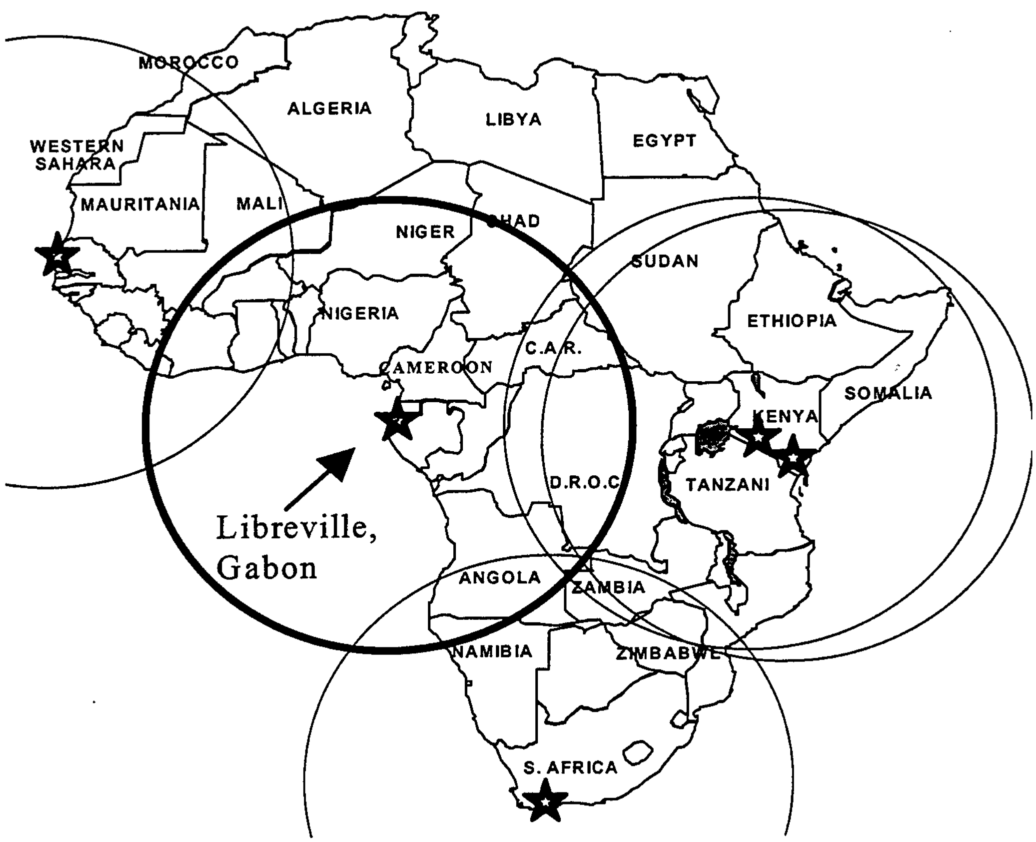

Figure 7. Adding Libreville ISB Coverage

only a 270,291 gallon storage capacity, of which only 159,849 gallons can be issued each day. Fortunately, Port Gentil, Gabon, is only 150 miles to the south and there is a possibility for leasing additional storage and transportation to Libreville from Mobil (Grant, 1998:5). DESC will need to explore how much additional storage and transportation can be procured in Port Gentil. Libreville's coverage spans the gap between Dakar, Nairobi/Mombassa, and Cape Town nicely. Strategic aircraft cannot make the trip from the U.S. direct to Libreville, but could make the trip with a stop for fuel at Lajes AB, Portugal, Ascension Island, or Dakar.

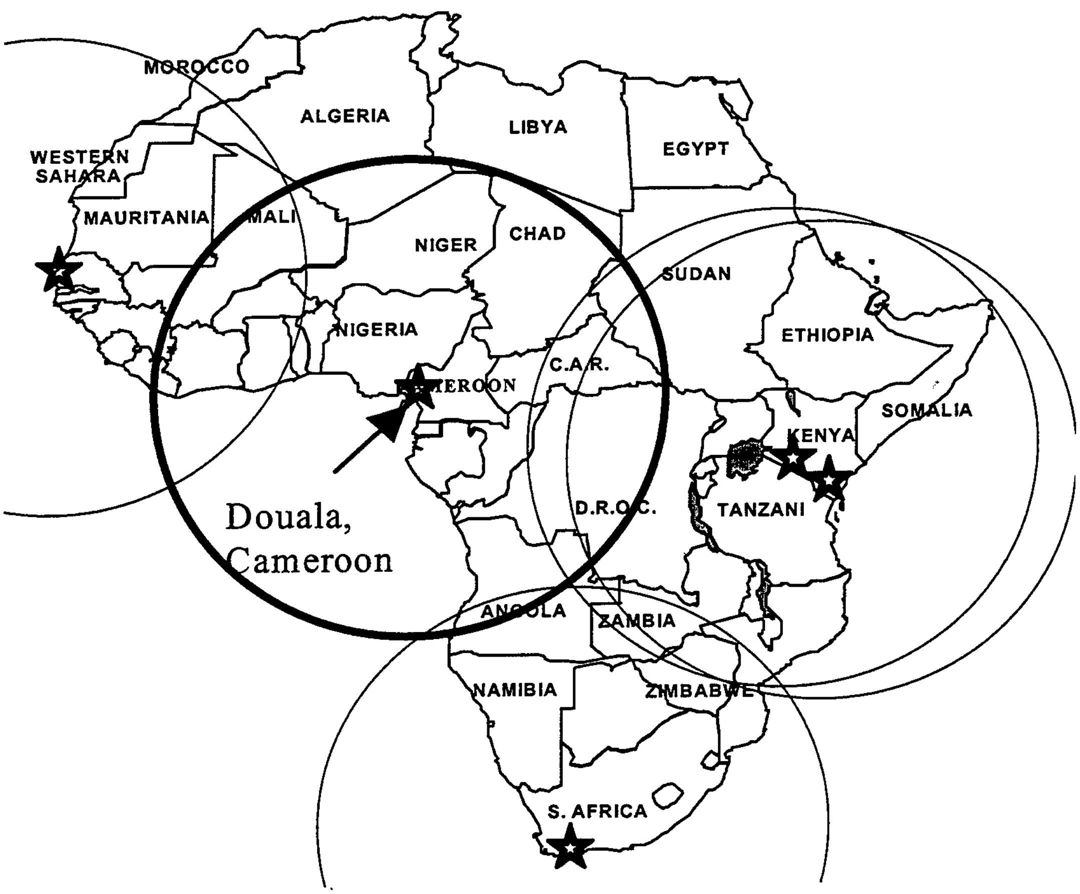

Figure 8. Adding Douala ISB Coverage

Douala, Cameroon is on the West Coast 213 miles north of Libreville. Douala has a storage capacity of 396,321 gallons and can issue half of that or 198,161 GPD. For U.S. usage, there is approximately 140,033 GPD available. Douala is resupplied via three dedicated trucks from the depot 40 minutes driving time away. Unfortunately, the storage capacity at the Depot was not available at the time of this writing and there is a question as to the validity of the fuel supply procedures at the depot. A tanker from Sonara Refinery in Limbe, 20 miles west of Douala, resupplies the fuel depot six times each month (Grant, 1998:4).

Located 120 miles east of Douala is Yaounde, the capital of Cameroon. Yaounde has better security, more ramp space, Embassy support, and lower fees than Douala. Unfortunately the fuel situation is less desirable at Yaounde. Storage capacity is only 158,528 gallons and only 59,448 GPD could be issued over a sustained period. All fuel for Yaounde travels via railcar once per month from the same depot mentioned above. It makes little sense to select Yaounde over Douala for a solution to a fuel shortfall problem (Grant, 1998:5).

Douala, Cameroon and Libreville, Gabon offer redundancy in two ways. They allow C-130 coverage over the area not covered by Dakar and Mombassa/Nairobi. But another important aspect is the fact that they are in different countries. If U.S. relations turn sour with Cameroon, then Gabon is a backup and vice versa.

Entebbe, Uganda is 281 miles east-northeast of Nairobi and 494 miles east northeast of Mombassa. We have experience operating out of Entebbe from Operation SUPPORT HOPE. A total of 71 C-5 missions, 196 C-141 missions, and 701 C-130 missions transited Entebbe between 24 Jul to 30 Aug 1994 (Starr, 1995:55-60). The fuel

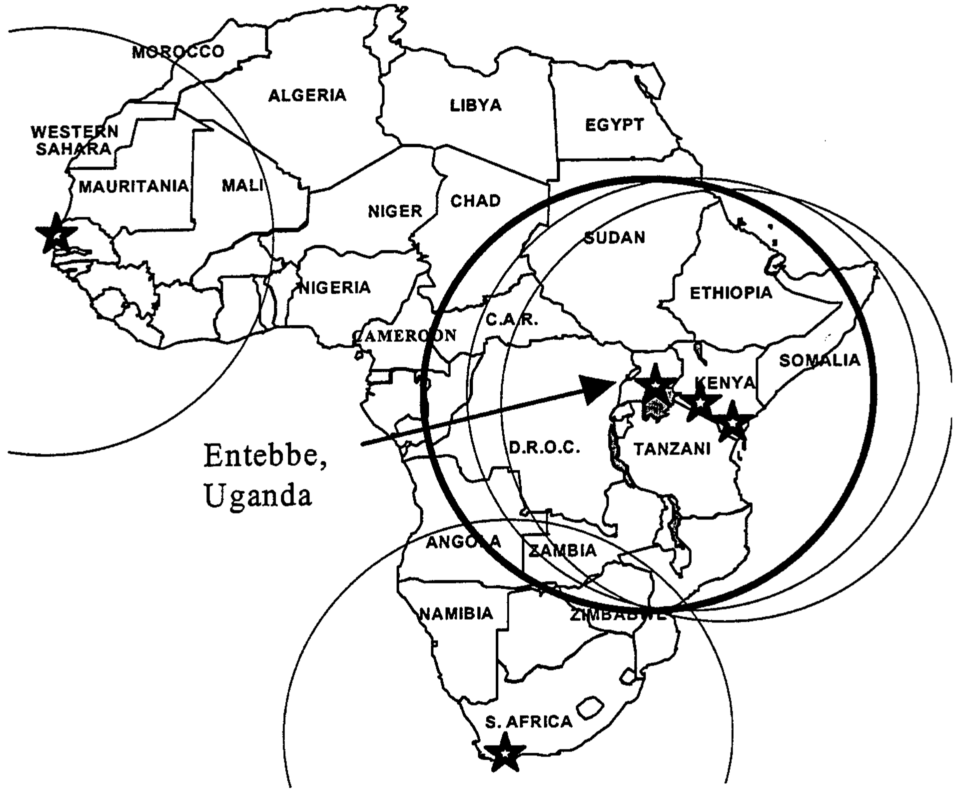

Figure 9. Adding Entebbe ISB Coverage

limitations that existed at Entebbe for Operation SUPPORT HOPE still exist today. Entebbe has only 591,839 gallons of storage capacity and a 79,264 GPD issue capability. Historical data shows that Entebbe has issued double that for a period of six days with 132,206 GPD going to U.S. aircraft (Grant, 1998:7). Fuel is supplied to Entebbe via pipeline from Mombassa to Eldoret, Kenya (140 miles directly east of Entebbe) and via truck from Eldoret to Entebbe. Pipeline transit time is ten days and truck transit time is another two days (Grant, 1998:6).

Although Entebbe offers redundancy with Nairobi and Mombassa and Entebbe is 494 miles westward nearer the center of the continent than Mombassa, Entebbe has limitations. First, all fuel destined for Entebbe has to pass through Kenya. If the on-hand stock of fuel is insufficient at Entebbe and diplomatic problems prevent Kenya from allowing fuel to pass through their country to support U.S. operations, there is no benefit to having Entebbe as an ISB. Storage capacity at Entebbe provides only two days operations per the ISB concept. Additional storage at Entebbe can increase the number of days of operations while we work out diplomatic problems with Kenya. However, if we solve the diplomatic problems with Kenya, the U.S. could then operate out of Nairobi/Kenya without waiting for the twelve day fuel transit time. The disadvantage is the increased fuel spent flying the distance from Nairobi or Mombassa over the top of Entebbe if the crisis happens to be in that direction.

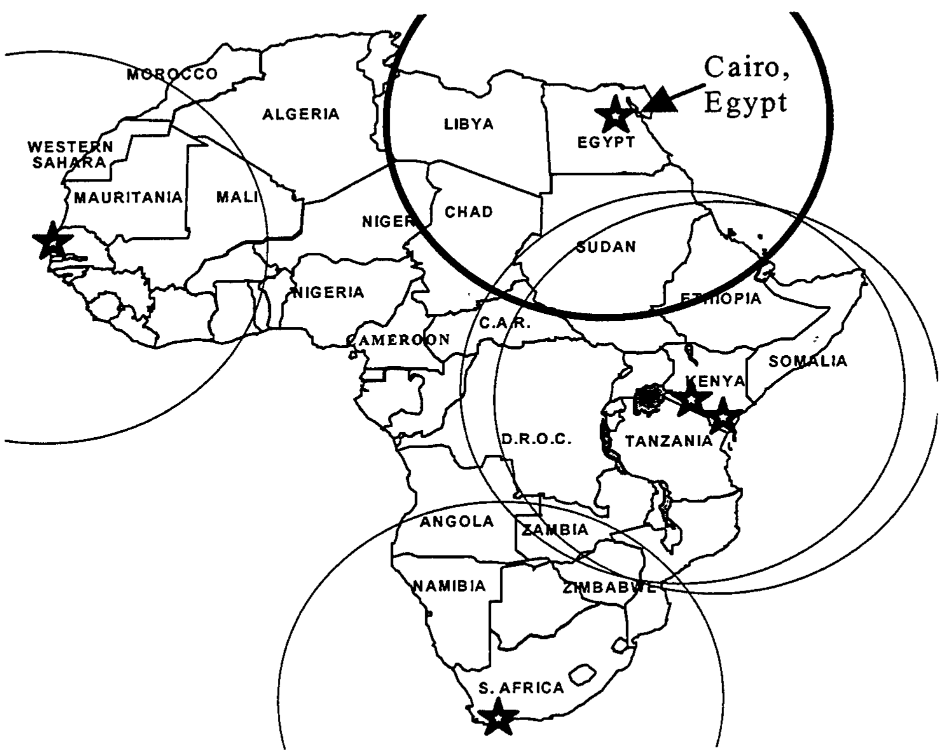

Figure 10. Adding Cairo ISB Coverage

Cairo, Egypt is the last of the lesser capability locations to be considered as an ISB and has been used extensively for operations into Africa and the Middle East. Current into-plane contract shows 100 GPD available for U.S. usage or about 40 percent of the ISB concept requirement. Cairo has two airfields useable for strategic aircraft, a military field and an international airport. Cairo offers coverage of the Northeast corner of the continent, including Libya, Sudan, and Chad. For strategic airlift from Europe, Cairo is reachable without air refueling or stopping to refuel. Similar to Dakar, refueling capability at Cairo provides a stepping off point for the whole continent. Cairo completes the location by location examination of the lesser capability ISB locations.

Of the seven lesser capability ISB locations, five make sense examining further.

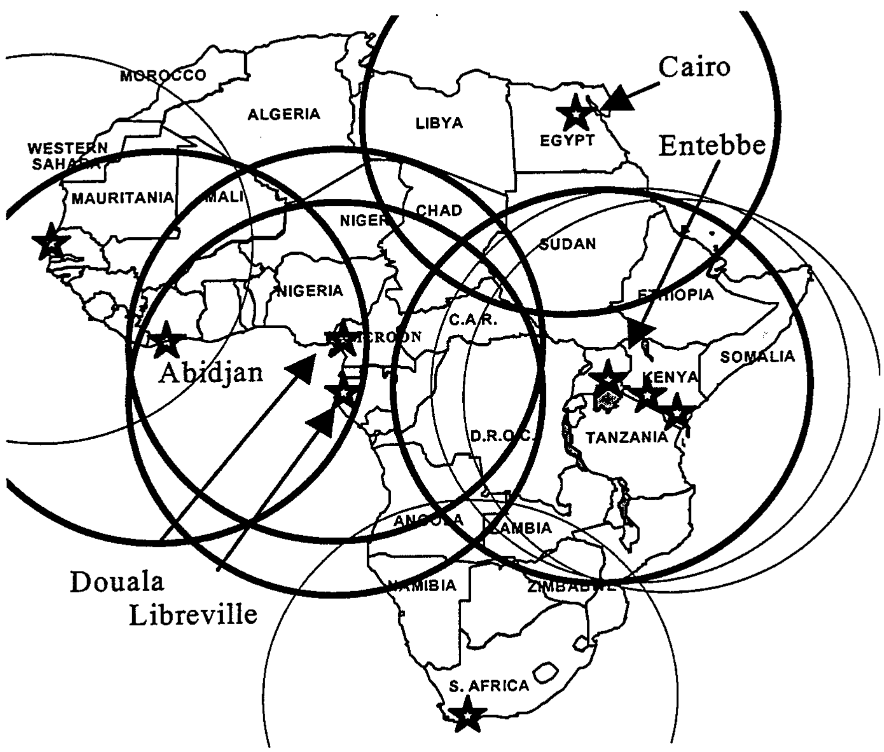

Figure 11. Adding Abidjan, Douala, Libreville, and Cairo ISB Coverage

One can eliminate Youande, Cameroon in favor of Douala for lack of fuel and excess storage reasons. One can also eliminate Cotonou, Benin for lack of fuel storage and small ramp space. This leaves Abidjan, Ivory Coast; Libreville, Gabon; Douala, Cameroon; Entebbe, Uganda; and Cairo, Egypt from our list of lesser capability ISB locations and Dakar, Senegal; Nairobi and Mombassa, Kenya; and Cape Town, South Africa from the list of high capacity ISB locations. How best can we prioritize the preceding list?

Coverage

With all ISBs added to the map, Algeria and Morocco are not covered. Those two countries are easily accessible across the Mediterranean Sea from Sigonella AB, Italy. The areas with single ISB coverage are the countries along the Northern Coast of the continent and the Southern most countries bordering and including South Africa. Most of the area with double coverage actually has triple coverage, raising the question of possible savings through elimination of some ISBs.

The most obvious overlap includes the three rings around Mombassa and Nairobi, Kenya and Entebbe, Uganda. Given the requirement to transport fuel through Kenya to get to Entebbe, the long lead-time to do so, and the lack of fuel storage at Entebbe, one could eliminate Entebbe as a possible ISB. The overlap coverage for Douala, Cameroon and Libreville, Gabon is similar to Entebbe's overlap with Nairobi and Mombassa with a small exception. Because both Douala and Libreville have their own in country depots, therefore the diplomatic problem of fuel having to transit another country en route to Douala or Libreville is not a problem. USEUCOM can have significant redundancy from

Abidjan with out either Douala or Libreville and improve fuel capacity at one or all of the other ISBs. If Libreville is eliminated, there is no loss of single coverage. If Douala is eliminated, there is a loss of coverage in Algeria and Northern Niger, both of which are reachable from Europe.

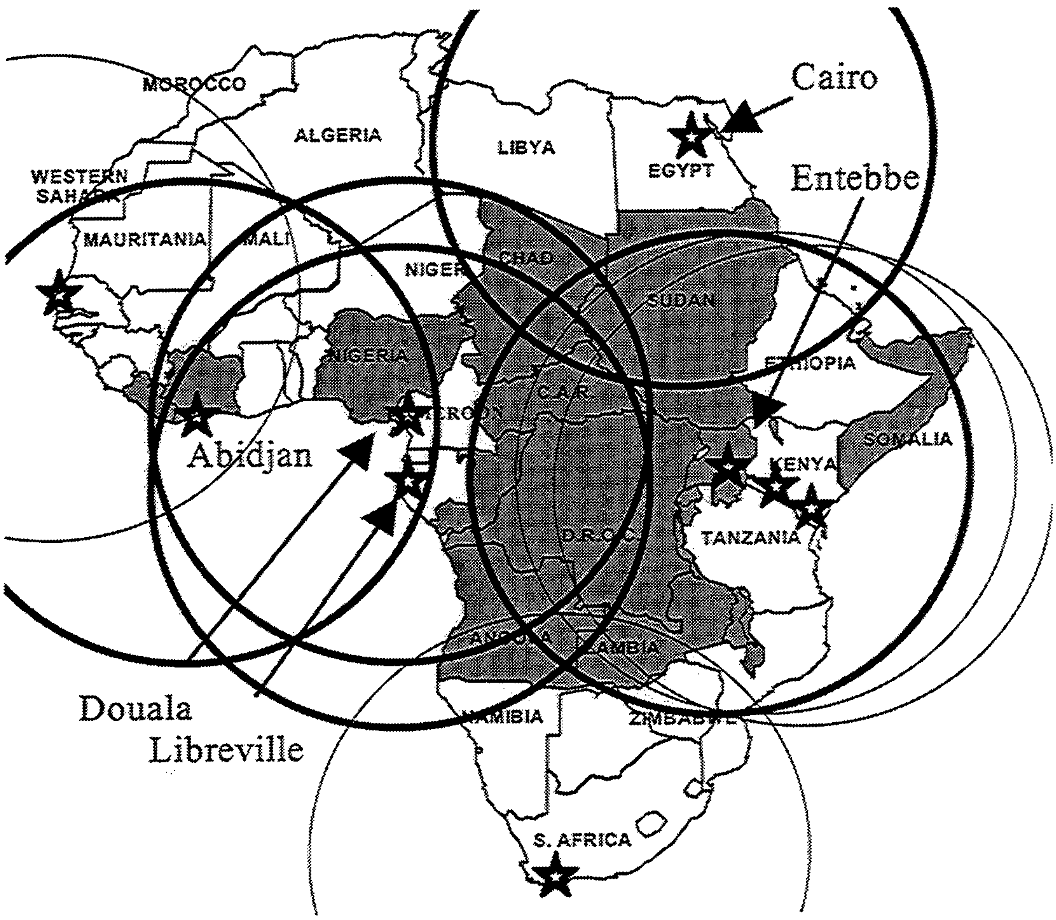

Figure 13. Adding Hot Spot Countries to ISB Coverage

Hot Spot Coverage

USEUCOM JPO designated a number of countries as "hot spots" due to their instability. ISB locations should provide coverage, and if possible redundant coverage for the "hot spot" countries (USEUCOM Joint Petroleum Office, 1999). Figure 12 shows the "hot spot" countries as well as the ISB rings. Note that all hot spots have at least double coverage and most have triple coverage if we include all possible ISBs. In the cases where there are areas of triple coverage, USEUCOM can consider elimination some ISB locations without impacting coverage of hot spots.

Analysis

Given the experience gained through Operation SUPPORT HOPE, there is potential for the ISB concept. However, there is a number of questions still to be answered.

The first question is how can the U.S. entice contractors at each ISB location to increase their storage capacity to meet the 2.42 million gallons designated in the concept? Because Dakar, Nairobi, Mombassa, and Cape Town can meet the daily requirements, it is not so important that they meet the storage requirements. However, it is important for the lesser capacity ISBs to increase capacity, given the reduced resupply capability. DESC is responsible for contracting per the CINC and Joint Staff's guidance, but the Joint Staff has disapproved funding for construction of build-to-lease storage.

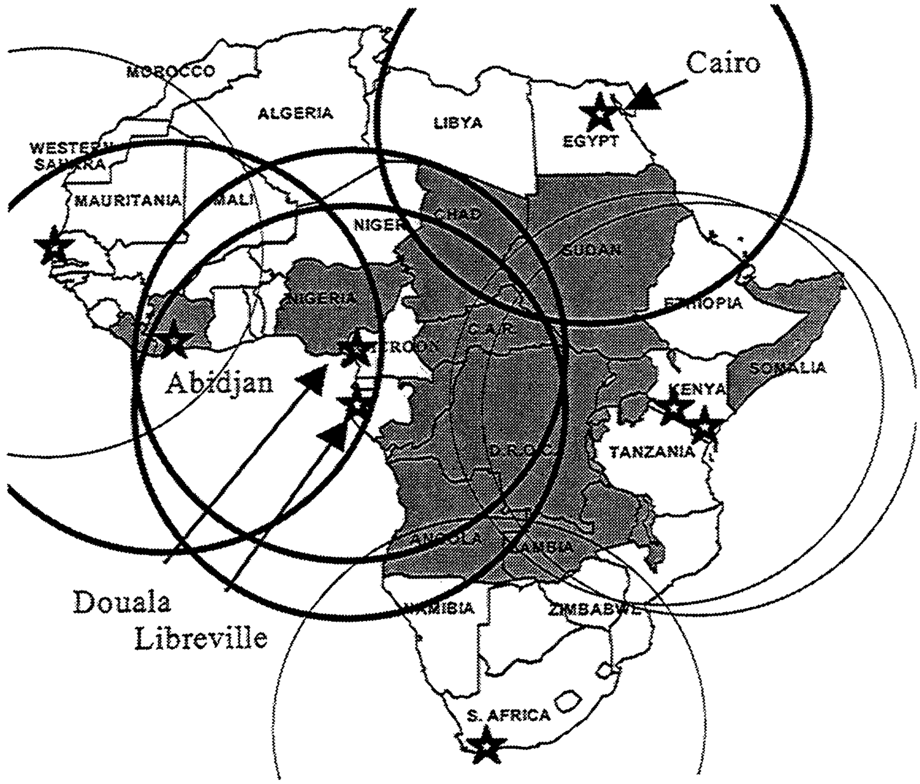

Figure 13. Eliminating Entebbe ISB Coverage

The second question is how many ISBs should the U.S. develop? There are a number of operational reasons for possibly eliminating ISB candidates beginning with Entebbe, Uganda. Eliminating Entebbe with no other changes results in loss of redundant hot spot coverage in a small portion of Northern Sudan and a small portion of Eastern Zambia. No single coverage is lost through Entebbe's elimination. The next choice for an ISB to eliminate is not as easy.

Coverage areas for Abidjan, Douala, and Libreville largely overlap. Abidjan is in one of the hot spot countries, which should concern a planner counting on access to and fuel in Abidjan. Elimination of Abidjan would have almost no impact on single hot spot coverage. However, there is a loss of redundant hot spot coverage in

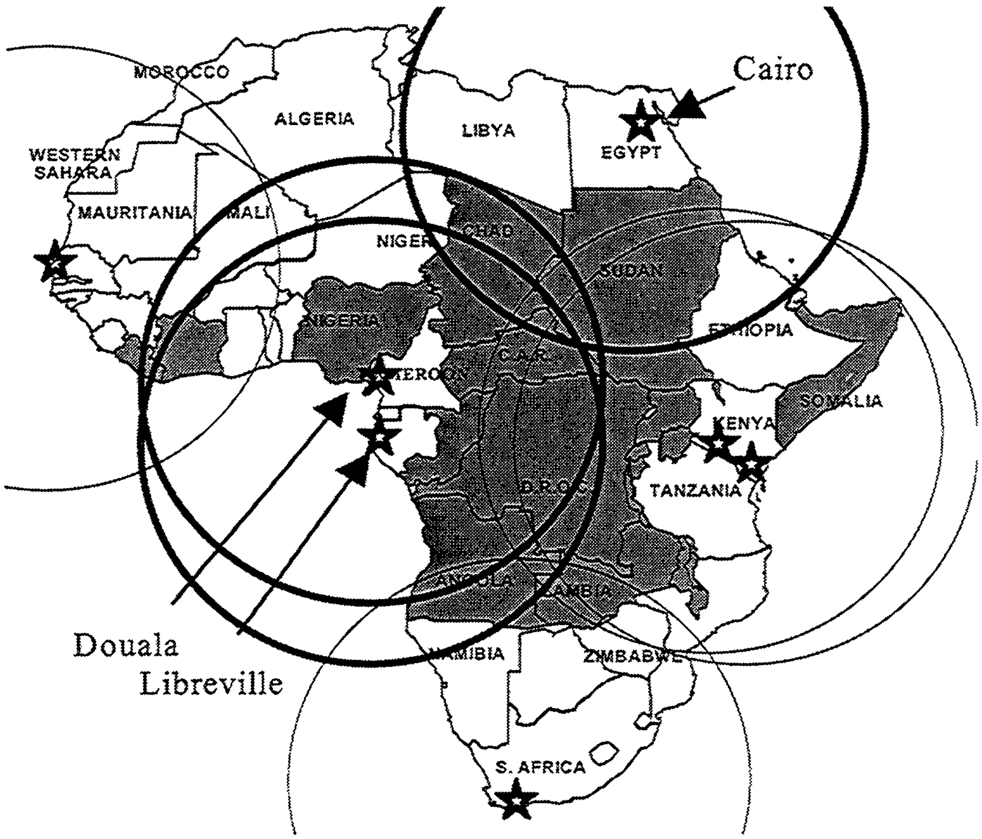

Figure 14. Eliminating Entebbe and Abidjan ISB Coverage

Liberia. Elimination of Douala results in a loss of redundant coverage of northern Chad, whereas elimination of Libreville results in a loss of redundant coverage in southern Angola, both countries being hot spots. Choosing one or two of these three ISB locations requires a risk analysis by USEUCOM's staff.

Cairo, Cape Town, Dakar, Mombassa, and Nairobi offer the only coverage for large parts of Africa and deserve more research to ensure their capabilities. Because DESC's team did not visit Cairo, Cape Town, Mombassa, and Nairobi, so additional research is advisable for those locations in particular.

Estimated Cost

The estimation of cost can be divided between the estimated cost for storage of 2.42 million gallons and the cost for guaranteeing a daily delivery of 242,000 gallons. Purchasing 2.42 million gallons at today's rate of 81 cents per gallon costs a total of $1.96 million. That cost would apply to each ISB location chosen. Unfortunately, only Nairobi has storage capacity available for that quantity. The Joint Staff's approval of purchasing fuel for future use Africa indicates its importance. Any fuel contractor in Africa would have to fund his own construction to meet the storage requirement, which may increase the per gallon price.

There would be additional costs for storing fuel. DESC would have to require the contractor to cycle the fuel through his stocks and DESC would have to periodically inspect the fuel. However, the U.S. can be certain that the fuel will be there when needed. And there would be ten days of fuel while the contractor ramps up deliveries.

The cost for guaranteeing a daily delivery of 242,000 gallons is not as easy to estimate. This option leaves to the contractor the option as to how to meet daily delivery quantities, but carries the risk of fuel contractors not being able to meet contractual agreements when needed. If the fuel is not available for an operation, the U.S. could sue for damages, but that does not help the war fighter in time of need. Additionally, there is some concern in the fuel community as to the legality of paying for guaranteed fuel availability. The taxpayer wants more than just a promise for his tax dollars.

One might estimate the cost as follows. If one estimates the fuel need to match that of Operation SUPPORT HOPE, the requirement would be 242,000 GPD over a 38 days. The cost of the fuel used would be approximately $7.5 million. If the U.S. had to pay 1 percent of that each year for the guarantee, the annual cost would be $75,000 for each ISB. There is no experience or historical basis for this estimate, just speculation after discussion with experts in the field. Also left unanswered is the amount of time allowed for the contractor to ramp up to the 242,000 GPD delivery rate.

Conclusions

DESC reports that the French military maintain strategic fuel stocks in Africa, but has no specific information as to the nature or costs of the contracts. At times the U.S. has dealt with the French government to release some of the fuel they control to be used for U.S. operations in Africa. Additional research into the French contracts may prove helpful, especially since the U.S. has no history for reasonable prices to pay for guaranteed fuel delivery.

One would be surprised if contractors were willing to increase storage capacity just to meet a one-time purchase of such a large quantity from the U.S. Therefore, the cost for purchasing the fuel would exceed the cost of the fuel alone. If the U.S. could guarantee fuel delivery for $75,000 each year, that seems a relative bargain.

IV. Offshore Petroleum Distribution System

Introduction

The Naval Sea Systems Command (NAVSEA) in conjunction with the Maritime Administration (MARAD) developed the Offshore Petroleum Distribution System (OPDS) in response to a JCS requirement to deliver bulk petroleum products ashore in remote locations (Gilmour, 1998). The principle component of OPDS is a specially equipped tanker ship capable of anchoring near shore and pumping petroleum to a Beach Termination Unit (BTU) on the shore. OPDS tankers can carry 12 million or 7 million gallons of JP-5 fuel depending on ship type. OPDS is a possible solution to the lack of fuel infrastructure in Africa.

Description of the System

The U.S. currently owns five OPDS vessels, the SS Potomac, the SS Petersburg, the SS American Osprey, the SS Chesapeake, and the SS Mount Washington. The Potomac and Petersburg are currently assigned to the Afloat Positioning Forces (APF) at Diego Garcia and Guam, respectively. The Chesapeake and Mount Washington are kept in the Ready Reserve Force (RRF) on a five day Reserve Operational Status (ROS) at San Francisco and Houston, respectively. The American Osprey is kept in a thirty day ROS in Port Arthur, TX. The Petersburg, Chesapeake, and Mount Washington are the same class of tanker and carry 12.9 million gallons of JP-5. The Potomac and American Osprey are of a second class of tanker and carry just over half the capacity, 7.2 million gallons (Cahill, 1999).

The system includes a single anchor leg mooring (SALM), four miles of six-inch internal diameter submersible hoseline, booster pumps and associated mooring, and handling equipment capable of delivering 1000 gallons per minute (GPM) to the beach. All equipment necessary for installation up to the BTU is carried on board the vessel (49th Quartermaster Group, 1997:7-1).

The SALM weighs 875 short tons and is carried just forward of the superstructure. The crew lists the ship to port to download the SALM. Then the SALM is lowered to the bottom by flooding buoyancy tanks. The SALM allows the OPDS ship to rotate 360 degrees while pumping petroleum. From the SALM the hoseline travels along the ocean floor and up the beach to the BTU (49th Quartermaster Group, 1997:7-1).

Once in place, the OPDS can deliver up to 1.2 million gallons per 20-hour day. The remaining four hours of each day are required for maintenance of the system. The OPDS vessel has to remain with the system for OPDS to operate; however, any military or commercial tanker can moor alongside the OPDS vessel and pump petroleum products through the system (Department of Defense, 1998:XI-5).

From the BTU, an Army Inland Petroleum Distribution System (IPDS) can be used to transport the petroleum inland as necessary. IPDS are generally deployed in 5-mile sets. Complete sets of IPDS equipment are kept aboard APF vessels in Diego Garcia and Guam (moored near the OPDS vessels), and additioanl reserve equipment is stored in Sierra Army Depot near Reno NV (Buck, 1999).

Limitations

The OPDS has a number of limitations. The system operates in water depths of 35 to 200 feet with a sea floor of mud, sand or coral of gradient of 1:2 to 1:500. Installation is limited to 5 foot vertical waves, 16 knots of wind, and 1.5 knots of current (NAVSEA, 1995:1-3). Maximum current speed is 4.0 knots and maximum wind speed is 40 knots. Operation is limited to sea state 5, or approximately 12 foot vertical waves and can survive but not operate in up to sea state 7, or approximately 40 foot waves. A temporary installation can be completed in 48 hours, but is limited to operation in sea state 3. A sea state 5 operable installation takes five days (Department of Defense, XI-5). The OPDS carries four miles of submersible hoseline, limiting how far the OPDS vessel can be moored from the shore and BTU. (49th Quartermaster Group, 1997:7-1).

Making OPDS Operational/Timeline

The OPDS vessel must cruise from its berthing location to the point of use. The nearest to African berthing location for OPDS vessels is Diego Garcia. OPDS vessels are capable of up to 15 or 16 knots, but more realistically average 13 knots (Cahill, 1999). Distances and cruise times to all coastal ISB locations are listed below.

Table 1. OPDS Vessel Cruise Time

Proposed ISB	Distance from Diego Garcia	Cruise time at 16 Knots	Cruise time at 13 Knots
Dakar, Senegal	7,043 nm	19 days 14 hours	22 days 13 hours
Abidjan, Ivory Coast	6,048 nm	15 days 18 hours	19 days 9 hours
Douala, Cameroon	5,703 nm	14 days 20 hours	18 days 7 hours
Libreville, Gabon	5,499 nm	14 days 7 hours	17 days 15 hours
Cape Town, S Africa	3,370 nm	8 days 19 hours	10 days 19 hours
Mombassa, Kenya	1,968 nm	5 days 3 hours	6 days 7 hours

(Distances in nautical miles calculated using FalconView3©)

Once in place with the proper sea state, SeeBees from an Amphibious Construction Battalion and divers from Underwater Construction Teams perform bottom surveys, install the conduit, and operate the BTU. The Navy package is approximately 50 men, not including support personnel or force protection personnel (Pollard, 1999).

The OPDS simply gets the petroleum to the beach. From that point, the Army installs and operates the IPDS. To determine exactly the equipment and number of containers needed for the IPDS, the Army must conduct an on-site survey. If APF IPDS equipment were used, it would arrive with the OPDS vessel; however, if the IPDS equipment comes out of Sierra Army Depot, delivery time would be especially long. For an exercise in Korea, transit from the Depot and setup time was 2.5 months. For a 5-mile set of IPDS over flat terrain, 50 twenty-foot containers of equipment and piping are required. More than 5 miles of IPDS are possible, and would require additional containers (Buck, 1999).

Once the IPDS equipment is offloaded at the site, an Army platoon of 35-40 personnel requires approximately 4 days to install and test the system (Martin, 1999). Once the IPDS is operational, the combined system is ready to pump fuel.

Total time to functioning of the OPDS includes survey time, vessel cruise time and setup time for OPDS and IDPS. Tables 2 shows best case time from execute to operation for the system.

Table 2. Best Case Total Time to Operation for OPDS/IPDS

Proposed ISB	Cruise time at 13 Knots	OPDS and IPDS Installation Time	Best Case Total Time to Operation
Dakar, Senegal	22 days 13 hours	4 days	26 days 13 hours
Abidjan, Ivory Coast	19 days 9 hours	4 days	23 days 9 hours
Douala, Cameroon	18 days 7 hours	4 days	22 days 7 hours
Libreville, Gabon	17 days 15 hours	4 days	21 days 15 hours
Cape Town, S Africa	10 days 19 hours	4 days	14 days 19 hours
Mombassa, Kenya	6 days 7 hours	4 days	10 days 7 hours

One way to shorten the time to operation was demonstrated at Mogadishu, Somalia. Mogadishu has a port with sufficient draft to handle OPDS vessels. The OPDS vessel was tied to the pier at Mogadishu and the hoseline was laid on top of the pier and the petroleum was pumped to waiting fuel trucks for transport to the airport. This significantly reduced the Army and Navy support packages required. It also eliminated the stringent installation limitations for sea state, current, and wind (Cahill, 1999).

Cost

Operation of OPDS costs approximately $32,000 per day whether it is cruising or in place pumping petroleum. If an APF ship is used to transport IPDS to the intended location, the cost is another approximately $32,000 per day of cruise. Over the 38 days of Operation SUPPORT HOPE, use of OPDS would have cost $1.216 million. Transportation of IPDS would have cost $640,000 for the ten day round trip from Diego

Garcia to Mombassa. Total cost adds up to $1.856 million. If an OPDS were taken out of ROS, there is an additional $150,000 activation/deactivation charge plus additional time en route (Cahill, 1999). The charge would be twice that if another ROS ship were used to transport IPDS equipment to the crisis location. Using the OPDS vessel as was done in Mogadishu is the most cost effective method at $1.216 million. Even though this figure seems high, it is less than air refueling or purchasing fuel.

Conclusions

Length of time from execute order to operation is the biggest drawback to OPDS. If the U.S. had waited for an operational OPDS to respond to in Operation SUPPORT HOPE, another 30,000 would have died during the ten day cruise and set up time. If the system could be deployed and used as was done in Mogadishu, the time becomes more palatable for HUMRO.

Another stumbling block for OPDS is its allegiance to a specific war plan. In order to obtain permission to use the system, the supported CINC must accept additional associated with the system no longer being available for his war plan. The SS American Osprey was diverted from its war plan duties to serve in Mogadishu (Cahill, 1999). The CINC may be less likely to commit his OPDS when American lives are not on the line.

In the case where there is no major port near the airfield or overland fuel supply capability, OPDS offers the sole solution for when the requirement goes into the millions of gallons.

V. Conclusions and Recommendations

Strengths and Weaknesses

Operation SUPPORT HOPE demonstrated how the air refueling aircraft of the AF give an unparalleled capability to the U.S. The air refueling force can be used on one side of the world today and on the other side of the world next week. The downside to using the air refueling force is the cost of operations and its limited availability for other operations.

At the time of this writing, the U.S., in conjunction with the United Nations, is fighting an air war with Serbia. For the week of 20 to 26 May 1999, the KC-135 commitment rate was 83 percent, 3 percent above the sustainable commitment rate of 80 percent for KC-135s. KC-10 aircraft were committed at 85 percent, equaling the KC-10 sustainable commitment rate (AMC TACC, 1999). The air refueling assets used in Operation SUPPORT HOPE might not be available if the U.S. tried to do it today. Fortunately, the U.S. is normally at peace. The air refueling assets accomplished the mission did the job during Operation SUPPORT HOPE. On only one day did airlift operations cease due to lack of fuel at Entebbe.

The USEUCOM initiative has a number of strengths. The initiative would guarantee fuel to support CINC objectives regardless of any U.S. war involvement. The initiative would guarantee availability of fuel when NGOs and other Nations are competing for the same fuel. However, the initiative requires money to be spent up front in anticipation of a HUMRO. Nairobi, Kenya is the only ISB with storage capacity greater than the 2.42 million gallon requirement, and there is U.S. money for increasing storage at any of the ISBs. Additionally the initiative places a burden on DESC to inspect the fuel on a regular basis.

If USEUCOM can contract for fuel delivery at the rate of 242,000 GPD with a short ramp up time, it becomes an attractive option for two reasons. Not having to store fuel eliminates the need to inspect and monitor the fuel. The U.S. would not have to pay for fuel that may never be used. And risk of loss of a valuable store of fuel due to political instability inherent in the region is eliminated. However, that option carries with it additional risk that the contractor cannot perform, degrading military capabilities for the war fighter.

OPDS capabilities to provide up to 12 million gallons of fuel are unparalleled. OPDS provides the only answer in remote locations where there is no fuel infrastructure available. OPDS is limited to use in the coastal regions. Transportation requirements for the 500 personnel and 50 container 5-mile IPDS set are significant. The long time to cruise and setup make quick response impossible. At a port with container download capability, setup time can be reduced. However, at a port capable of handling the OPDS vessel, the option of pumping fuel from onboard down the pier to fuel trucks for movement to the airfield is attractive. Because OPDS is part of our capabilities like the air refueling force, there are no marginal costs until activated.

Cost Comparison

The following table includes costs over and above the fuel costs and sunk operational costs for the various options covered in this paper. The costs for air refueling during the 38 days of Operation SUPPORT HOPE are reflected as accurately as possible.

The cost for USEUCOM's initiative reflects having a single ISB at Entebbe, Nairobi, or Mombassa. That cost is suspect because it assumes that USEUCOM picked one correct location that could be used for the Rwandan HUMRO. In practice, the annual and maintenance costs multiply by the number of ISBs selected. Maintenance costs for stored fuel and the cost for guaranteed deliveries are suspect because no historical cost exists for such an option. The OPDS cost in the table reflects the least cost option of using the APF vessel(s) at Diego Garcia and cruising to Mombassa, the closest location considered in Africa.

Table 3. Cost Comparison

Option Examined	One time Additional Cost	Annual Maintenance (*estimated at 1% of fuel cost*)	Cost When Used
Air Refueling as used during Operation SUPPORT HOPE	None	None	$2.02 million
USEUCOM Initiative to Purchase and Store 2.42 Million Gallons at ISBs	$1.96 million	$19,602	None
USEUCOM Initiative to Guarantee 38 days of 242,000 GPD Fuel Delivery	None	$75,000	None
OPDS with IPDS	None	None	$1.86 million
OPDS parked at the Pier	None	None	$1.22 million

Upon examination, it is clear that there are no inexpensive options. Interestingly, almost all options cost near $2 million. A notable exception is the option to contract for guaranteed fuel delivery; however, the actual cost may differ greatly from the estimate. If USEUCOM stores fuel at several locations then the cost could be several times higher than the cost listed. Air refueling and OPDS offer capability without spending any money in anticipation of future need.

Areas for Further Inquiry

Because the cost of guaranteed fuel delivery appears so inexpensive, that option deserves further investigation. The legality of paying for a promise needs to be resolved. This promise to provide fuel is not significantly different than the promise by Commercial Reserve Air Fleet (CRAF) to provide airlift upon demand. Perhaps DESC can use CRAF as a model for their fuel guarantee program.

The OPDS program manager is examining a program for eliminating the biggest headache of the OPDS setup—the SALM. Elimination of the SALM would reduce manpower requirements and time for setup. Procedures for use of the OPDS tied to the pier as was done in Mogadishu should be documented in Joint Publication 4-06.1. The option is attractive and may be desirable for other fuel shortage problems as well.

Recommendations

Most of the African continent can be covered by C-130s flying out and back sorties from Dakar, Senegal, Mombassa and Nairobi, Kenya, Cairo, Egypt, and Cape Town, South Africa. The problem area is on the West Coast from Angola north and west to the Ivory Coast. USEUCOM's initiative is a good solution for that region.

The airfields that should be considered are Abidjan, Ivory Coast; Douala, Cameroon; and Libreville, Gabon. The storage capacities at those locations are far short of the desired 2.42 million gallons, and the Joint Staff has not approved funding construction of additional storage facilities. This leaves one option. USEUCOM should research fuel delivery guarantees at all three locations. USEUCOM should find innovative solutions for the fuel contractors at those locations to decrease ramp up time and increase throughput. To ensure the fuel contractors can meet contractual demands, USEUCOM should regularly exercise at those locations.

The estimated cost of $75,000 per location is a real bargain compared with the $2 million for using air refueling, OPDS, or storing fuel. The price is likely an underestimate and the actual price would be higher. However, the costs will differ for each location depending on what the fuel contractors have to do to improve their throughput weak link. Even if the cost is double the estimate and all three locations become ISBs, $450,000 per year is a reasonable price to improve fuel infrastructure at key locations to guarantee fuel availability ability to operate in Africa.

There are no easy or inexpensive solutions to fixing infrastructure problems in remote regions of the world. The very reason the U.S. has air refueling and OPDS is because the military may be called upon to respond anywhere, anytime. Unless fuel guarantees can be purchased for a reasonable cost at key locations, the U.S. should rely its air refueling and OPDS capabilities.

Bibliography

-----. "AMC Airlifts Aide to Rwanda," Airlift/Tanker Quarterly, Volume 2, Number 3:18 (Summer 1994).

AMC TACC/XOCB. "1000L Provide Assistance Update." Scott AFB, 26 July 1994.

AMC TACC/XOOX. "SUPPORT HOPE Aircrew Brochure Change One." Scott AFB, 29 July 1994.

AMC TACC/XOOX. "SUPPORT HOPE AMC Aircrew Handout Number One." Scott AFB, 2 August 1994.

AMC TACC/XOOX. "SUPPORT HOPE AMC Aircrew Handout Number Three." Scott AFB, 11 August 1994.

AMC TACC. "AMC Operations Summary." Scott AFB, 20 May 1999.

AMC/HO. AMC History for 1992 Through 1994, Volume 1. Scott AFB, no date given.

AMC/QMIF. AMC Command Data Book. Scott AFB, November 1998.

Buck, John M. Commander, 267th Quartermaster Company, Fort Lee VA. Telephone Interview. 18 May 1999.

Cahill, William H. Offshore Petroleum Distribution System manager, Maritime Administration, Washington DC. Telephone Interview. 12 May 1999.

Connaughton, Richard M. "Military Support and Protection for Humanitarian Assistance, Rwanda, April-December 1994," Strategic & Combat Studies Institute, The Occasional, Number 18. Camberley UK,1996.

Grant, James F., Jr. "Trip Report-Africa Fuel/Subsistence Site Survey." Stuttgart, Germany 11 February 1998.

Department of Defense. Joint Tactics, Techniques, and Procedures for Joint Logistics Over-the-Shore. Joint Pub 4-01.6. Washington: GPO, 12 November 1998.

FalconView3©. Version 3.01, IBM, CD-Rom. Computer Software. Georgia Tech Research Corporation, Atlanta 1998.

Gilmour, Paul. OPDS Program Manager, Office of Ship Operations, Maritime Administration. "Offshore Petroleum Distribution System." Unpublished article, n. pag. http://www.lee.army.mil/quartermaster/index.html. 6 April 1998.

Hurd, Bruce E.. KC-10 Mission Commander at Harare, Zimbabwe. Personal Interview. 18 February 1999.

Jareb, Anthony M. Logisitics in Operation RESTORE HOPE. Alexandria: Center for Naval Analyses, 1994.

Martin, Edgar E. Training Manager for Inland Petroleum Distribution System, Radian Corporation, Alexandria VA. Telephone Interview. 13 May 1999.

Mattox, Keith E. Chief, Joint Petroleum Office, United States European Command, Stuttgart, Germany. Personal Interview. 16 April 1999.

National Defense University. Strategic Assessment 1998. Washington: GPO, 1998.

NAVSEA Systems Command. OPDS General Operations and Maintenance, Technical Manual Volume Two. NAVSEA T9540-AE-OM1-020/OPDS. Washington: GPO, 31 January 1995.

Pollard, Daniel. Assistant Operations Officer, Amphibious Construction Battalion Two, San Diego CA. Telephone Interview. 20 May 1999.

Peck, Ronald E. Tactical Airlift Control Element Commander at Entebbe, Uganda for Operation SUPPORT HOPE, Virginia Beach VA. Telephone Interview. 17 May 1999.

Reese, Robert J. Joint Task Force SUPPORT HOPE Lessons for Power Projection. Fort Leavenworth, 1995.

Schroeder, Daniel R. Operation SUPPORT HOPE After Action Review. Stuttgart, Germany: USEUCOM 1994.

Starr, Charles L. Operation SUPPORT HOPE. Travis AFB CA: 60 AMW Historian Office, 1995.

United States European Command. USEUCOM Strategy of Readiness and Engagement. Stuttgart Germany, 1998.

USEUCOM Joint Petroleum Office. Extracted from unpublished Joint Petroleum Office Briefing Slides with text, n.pag. 16 April 1999.

Wilt, Dean F. Defense Energy Supply Center, Contingency Operations Officer, Europe. Telephone Interview 15 December 1998 and 20 May 1999.

49th Quartermaster Group. "Liquid Logistics Planner's Guide." 15 December 1997.

Vita

Major Steven C. Dye was born on 7 November 1963 in Pirmasens, Germany. After graduation from The York School in 1981, he entered the United States Air Force Academy in Colorado Springs, Colorado. In 1985, he graduated from USAFA with a Bachelor of Science in Astronautical Engineering. He was awarded a Master of Arts in Business from Webster University in 1994.

Following his commission, Major Dye graduated from Undergraduate Pilot Training at Williams AFB, Arizona in July 1986. His first assignment was to Travis AFB, California piloting the C-141 Starlifter. In February 1989, Major Dye was assigned to Reese AFB, Texas as a T-38 Instructor Pilot where he served as Flight Commander and Chief of Check Section. In July 1992, Major Dye was assigned to Charleston AFB, South Carolina, where he served as C-141 Instructor Pilot, Flight Commander, and Chief of C-141 Flight Safety for the 437th Airlift Wing.

In July 1996, Major Dye moved to Scott AFB, Illinois to become an Operations Inspector with the Air Mobility Command Inspector General. He also served as Executive Officer for the Inspector General. Major Dye is a Senior Pilot with over 3,500 flying hours. He was selected by Air Mobility Command to attend the Advanced Study of Air Mobility program in 1998. Major Dye has been assigned to the United States Transportation Command at Scott AFB, Illinois.

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13. ABSTRACT *(Maximum 200 words)*

Airlift operations into Africa are very fuel intensive due to the great distance from the U.S. to the Africa as well as size of Africa itself. When combined with a very poor fuel infrastructure in Africa, makes airlift operations increasingly difficult. United States European Command requested this study to examine methods for meeting the fuel requirement for a humanitarian relief operation in Africa.

The three methods include air refueling as was done in Operation SUPPORT HOPE, a new initiative from United States European Command, and Offshore Petroleum Distribution System. Operation SUPPORT HOPE, humanitarian relief of Rwandan refugees, is examined for two reasons. First, it is the model for the expected airlift for just such an operation. Second, Operation SUPPORT HOPE was considered a success, so the methods may be the best possible solution. United States European Command's initiative is to either store fuel or contract for guaranteed fuel delivery at several locations in Africa. The final method examined is using the Offshore Petroleum Distribution System (OPDS). The OPDS is a specially equipped tanker ship capable of mooring four miles from shore and pumping aircraft fuel to the shore. The paper examines each option in terms of operational considerations and cost.

The paper concludes with the finding that USEUCOM's initiative would be worthwhile in one or more of three locations, Abidjan, Ivory Coast; Douala, Cameroon; and Libreville, Gabon. Air refueling is the best solution for short notice relief operations elsewhere. OPDS is the best solution only in remote locations.

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