STRATEGIC AIRLIFT EN ROUTE ANALYSIS TO SUPPORT THE GLOBAL WAR ON TERRORISM USING A VALUE FOCUSED THINKING APPROACH

THESIS

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Abstract

The Global War on Terrorism (GWOT) has yielded new challenges to the United States' strategic airlift infrastructure. The network of en-route airfields that serve as refueling and maintenance stops were designed primarily to service relatively static Cold War requirements. However, the GWOT has resulted in the need for an infrastructure that is responsive to a highly dynamic environment. This research uses a "value focused" methodology to identify en-route airfield locations that simultaneously maximize cargo throughput capability while possessing a high degree of adaptability to volatile cargo delivery requirements.

To My Husband, My Strength,

Thank you.

Acknowledgements

I would like to say thank you to my advisor, Lt Col Staats, for his guidance and patience in this long process. Thank you to Maj Charley Schlegel and Maj Alex Miravite whose expertise allowed me to understand the strategic airlift mission and finish on time.

MaryKathryn W. Tharaldson

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I. Background

The strategic airlift En Route System (ERS) is a network of airfields throughout Europe and the Pacific used to support airlift missions unable to travel non-stop between the origin and the destination airfields. These bases are stopping points along a flight path allowing the aircraft to refuel, obtain maintenance, and for the aircrew to rest if necessitated by maximum crew day limitations. The ERS is in constant use to support airlift missions including peacetime operations, such as humanitarian and relief efforts, as well as wartime missions.

The ERS consists of bases built during World War II, with some additions during the Vietnam War in the Pacific region (McVicker, 2002), to access Southwest and Northeast Asia areas, such as Iraq and Korea, respectively. After the Cold War, the military budget declined due to a perceived reduction in risk of conflicts and the reduced need for a large standing military. Bases around the world were closed and maintenance budgets were reduced (GAO, 2001) for the remaining bases, whose facilities have been declining since the early 1990s. Aging equipment and reduced manpower leads to aircraft delays and reduced cargo flowing through the system (McVicker, 2002).

In 1998, the European En Route Infrastructure Steering Committee (EERISC) was formed to examine the condition of European bases. This committee constructed a "six lose one" basing strategy to support strategic airlift through Europe. This strategy chose 6 bases, Ramstein Airbase (AB) and Spangdahlem AB in Germany, Rota Naval Air Station (NAS) and Moron AB in Spain, and Royal Air Force (RAF) Mildenhall and RAF Fairford in the United Kingdom (UK), such that if any one of the bases is unable to operate due to factors such as weather, political access, and airfield repairs, the remaining five can be utilized while maintaining overall throughput (McVicker, 2002). EERISC also proposed a plan for improvements and upgrades of these bases to meet increasing military demands. These upgrades are scheduled for completion in 2006. In 1999, the Pacific En Route Infrastructure Steering Committee (PERISC) was created to investigate bases in the Pacific region. Due to the lack of land masses in the Pacific region, PERISC designed a “two lose one” routing strategy. That is, the committee chose a Northern Pacific route through Elmendorf Air Force Base (AFB) in Alaska and a Mid-Pacific route through Hickam AFB in Hawaii, so that any mission flying west can travel through one of these two en route bases to reach its final destination. PERISC also proposed a plan for the rejuvenation of other Pacific en route locations to meet increased military demand, with completion planned for 2008.

The current ERS, as developed by EERISC and PERISC, was built with existing Cold War assets focused on Asia. Current events, such as the Global War on Terrorism (GWOT) and the December 2004 tsunami in Southeast Asia, have exposed inadequacies in the en route infrastructure that have been developing since the 1990s. In particular, the GWOT presents a new worldwide scenario that the en route infrastructure was not designed to support. As terrorists spread fear to all corners of the earth and more countries need US assistance, the en route infrastructure must give the US the ability to fly anywhere in the world as quickly and efficiently as possible. As a result, United States Transportation Command (USTRANSCOM) is focused on improving the current ERS to extend the military’s reach with more effectively positioned bases.

Problem Statement

Previous research examined the en route location question using two methods. The first used a goal programming type approach to evaluate 25 potential en route sites (Sere, 2005). The factors assessed in this research were distance, measured as the longest distance between the origin and the en route or the en route and the destination; maximum on ground parking (MOG); fuel availability; the number of airfields within a predetermined “safe” distance; diplomatic relations, defined as the relations between the US and the nation of interest as determined from a Department of State website; and the distance of the en route to the closest seaport. This research weighted and scored each factor for each base according to available information. These scores were then compared and each potential en route site ranked to determine the overall “best” en route location.

The second research effort focused on the throughput aspect of the 25 en route locations evaluated by Sere (Voight, 2005). Voight evaluated the throughput of these locations to determine the bases with the maximum potential to increase the throughput of the ERS and best support the US military’s global reach capabilities. The factors assessed in Voight’s research were the airlift cycle, defined as the flight of the aircraft from the origin through the en route to the destination back through the en route ending at the origin; the spacing of the aircraft in the airlift cycle; and the throughput per day for each en route location.

This research improves the previous efforts by using a Value Focused Thinking (VFT) methodology to obtain a detailed analysis of each location and its characteristics.

The research examines the decision maker's preference structures to obtain a comprehensive model that rank orders a set of alternatives.

Research Questions

To evaluate various en route sites, many factors must be taken into account and several main questions must be answered. The questions motivating this research are:

- What bases will extend and strengthen the En Route System to meet the current and future needs of the US military?
- For each geographical region, what base networks offer the most effective route for cargo delivery?
- What values are important characteristics for an en route base?
- Which factors are most important and by how much?

The remainder of this document is organized as follows. Chapter II presents the literature and previous research that was reviewed pertaining to the en route system. Chapter III reviews the methodology used to approach this problem. Chapter IV examines the results and analysis obtained by using this methodology. Finally, Chapter V presents the conclusions and recommendations of the study.

II. Literature Review

This chapter begins with a review of the history of the en route system since the early 1990s and an overview of the current en route system. This is followed by a discussion of recent academic research of the en route structure in light of the GWOT. Finally, a brief background of value focused thinking is given to guide the reader through the process used in this research.

History of the En Route System

The end of the Cold War era brought about a perception in the United States of prevailing peace. Thus, the government reduced the number of overseas bases and the budget for those that remained. This reduction led to the deterioration of bases around the world and a decreased global reach capability. The bases in Europe and the Pacific that were used as stopping points for global travel, known as the en route system (ERS), suffered these same consequences. After years of neglect, Air Mobility Command (AMC) declared 1997 as "The Year of the En Route System" drawing attention to these bases in an attempt to increase funding (GAO-01-566, 2001:2).

OPERATION DESERT STORM underscored the shortfalls of the existing en route system in supporting large operations. The system relied on a select few airfields and was easily disrupted by weather and airport delays (McVicker, 2002:5). The deterioration of the airfields and the inability of the system to support large operations led to the evolution of the European En Route Infrastructure Steering Committee (EERISC) and Pacific En Route Infrastructure Steering Committee (PERISC) in the late 1990s. The en route steering committees have proven valuable in the effort to develop and maintain an en route system to meet the needs of a military having an ever expanding role.

Current En Route System

The current en route system was developed using the "lens" concept. An arc is drawn 3,500 nm from the US origin base and a second arc is drawn from the destination base in the theatre of operations. The intersection of these two arcs creates a lens, the feasible region for an en route base between the selected origin and destination. The range of 3,500 nm was determined based on the nominally limiting flight range for a C-17 carrying a load of 45 short tons or 90,000 pounds (McVicker, 2002). While this concept reveals the bases of the European region, the concept does not work for the Pacific area due to the lack of land masses. Thus, the strategy developed by PERISC uses the en route bases to support routes through other bases in Japan and Guam. Figure 2.1 displays the European and Pacific En Route Systems.

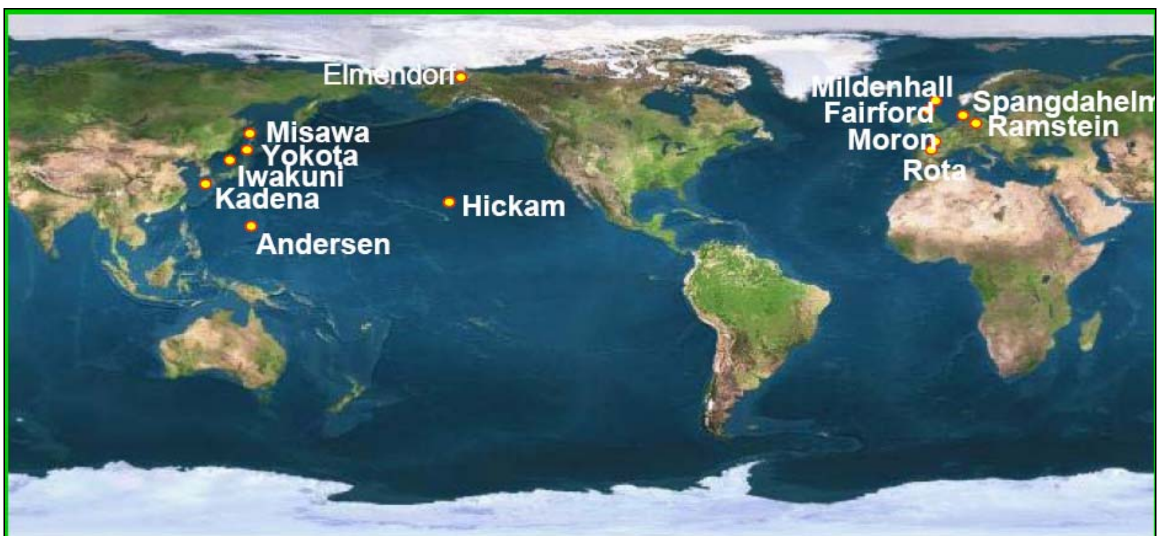


Figure 2.1. European and Pacific En Route Systems (Sere, 2004).

Previous Studies on the En Route System

General Accounting Office Report

In 2001, the General Accounting Office (GAO) published a report on the Management Focus Needed on Airfields for Overseas Deployments. One focus of this study was "whether en route airfields have the capacity to meet the requirements of the National Military Strategy…" (GAO 2001:1). The results showed that the Department of Defense (DOD) predicted considerable shortfalls in the En Route System's (ERS) capabilities due to lack of ramp space, deteriorating fuel pumping capacity and limited personnel and equipment. Improvements, completed in 2005, and continued development efforts (Ralston, 2002) of the en route bases serve to strengthen the ERS for present and future operations. These improvements significantly reduced the shortfalls when considering the national military strategy of two simultaneous major theater wars. However, the current Global War on Terrorism (GWOT) has considerably changed the nation's focus and increased the military's required global reach.

En Route Strategic Plan

EERISC and PERISC have independently developed and improved their respective en route systems. The "En Route Strategic Plan" compiled analyses of the ERS bases to provide an overall assessment of the ERS since OPERATION DESERT STORM and to review the actions taken to reduce its deficiencies (McVicker, 2002).

The "En Route Strategic Plan" provides a detailed summary of the improvement and modernization plans developed by EERISC and PERISC. The deterioration the Pacific bases have experienced over the years includes decaying fuel pipelines and runways. The European bases have seen improvements due to more recent use in military operations but are still unable to adequately support the expanding military involvement around the world. (McVicker, 2002).

Interim Brigade Combat Team Deployment Analysis

At the request of the Army Director of Force Projection and Distribution, USTRANSCOM conducted a study on the ability to deploy of the Interim Brigade Combat Team (IBCT) "within 96 hours of the first aircraft wheels up and begin operations immediately upon arrival" (IBCT, 2002:1) at the destination. The major findings focused on the effects of fleet size, ammunition, and weight on IBCT closure time; a significant finding was included about the ERS. It was found that airfields outside the accepted ERS had to be used to reach remote locations. Thus, the ERS is unable to meet the IBCT goals without improvement to the en route airfields (IBCT, 2002). The IBCT report validates the concern and focus the ERS is receiving.

Recent Academic Research

The Global War on Terrorism (GWOT) has highlighted the en route system's inability to support large operations and enable the military to reach far corners of the world. Sere developed a goal programming type model to select appropriate en route bases that will allow the US military to perform operations more efficiently (Sere, 2005).

Goal programming is a method of evaluating the achievement of more than one goal or objective. This method searches for compromise solutions between objectives that can not be simultaneously optimized. First, the decision variables are determined and the constraints or goals, with their target values, are defined. The alternatives are evaluated by these constraints and the outcome is determined by finding a compromise between all the goals such that the weighted sum of the deviations is minimized

(Anderson, Sweeney, Williams, 2003:688). Additionally, a rank ordering (by increasing weighted deviations) can be attained for the set of alternatives.

The goals and associated targets, as defined in Sere's work, are shown in Table 2.1.

Table 2.1. Goal Programming Goals and Targets (Sere, 2005:16).

Goal #	Goal	Symbol	Range	Target	Negative Deviation	Positive Deviation	Negative Weight	Positive Weight
1	Critical leg, $\max(l_1, l_2)$	L	$D/2 \leq L \leq D$	$D/2$	d_1^-	d_1^+	0	w_1^+
2	En route wide-body aircraft parking MOG	m	$0 \leq m \leq 20$	6	d_2^-	d_2^+	w_2^-	0
3	En route fuel capability	f	$1 \leq f \leq 3$	2	d_3^-	d_3^+	w_3^-	0
4	En route country diplomatic relations	r	$1 \leq r \leq 3$	3	d_4^-	d_4^+	w_4^-	0
5	En route proximity to coastal seaports	c	$1 \leq c \leq 3$	2	d_5^-	d_5^+	w_5^-	0
6	Airfields within **1,750** miles of en route	a	$0 \leq a \leq 1{,}500$	500	d_6^-	d_6^+	w_6^-	0

Three measures are continuous: critical leg, en route wide-body aircraft parking MOG, and airfields with 1,750 miles of the en route. However, several measures are evaluated using discrete levels, as shown in Table 2.2.

Table 2.2. Discrete Variables (Sere, 2005:18-20).

Measure	Levels
Diplomatic Relations	1 = Poor Relations 2 = Good Relations 3 = Exceptional Relations
Fuel	1 = Poor Capability 2 = Average Capability 3 = Considerable Capability
Proximity to Coastal Seaport	1, 2, or 3 as determined by JPO[1] at USTRANSCOM[2]
Notes: 1. JPO: Joint Petroleum Office 2. USTRANSCOM: United States Transportation Command	

Sere then evaluated 25 potential en route locations and 16 locations currently used as en routes in Europe and the Pacific. These en route bases were evaluated using four origins and eight destinations located in eight geographical regions. The results indicated six locations; Seeb International and Thumrait, Oman; Burgas, Bulgaria; Constanta, Romania; Bahrain international, Bahrain; and Kuwait International, Kuwait; to be superior locations for en route bases (Sere, 2005:72). These six bases showed the least deviation from the specified goals and targets.

Throughput is also an essential factor in selecting an en route base due to the large volume of personnel and material that must be moved during any type of operation. Voight evaluates the throughput of 14 potential en route bases to determine the bases with the highest throughput capabilities (Voight, 2005). An Excel-based tool was developed to calculate the daily amount of cargo that can be delivered from an en route to a destination. Inputs to the model are origin airfield, potential en route bases, destination airfield, and desired strategic airlift fleet (Voight, 2005:3). Measures analyzed in this analysis are shown in Table 2.3.

Table 2.3. Virtual Throughout Model (VTM) Measures (Voight, 2005:18-22).

Measure	Definition
Airlift Cycle	The trip from the origin through the en route to the destination, back through the en route ending at the origin
Cycle Time	Time required to complete airlift cycle
Flow Interval	Intervals at which the aircraft enter the airlift cycle
Fuel Burn Rate	Rate the aircraft burns fuel during flight
Takeoff Weight	Weight of aircraft takeoff
Flight Distance	Total distance of flight

The Virtual Throughput Model (VTM) calculates the daily cargo throughput for four scenarios: "operations depending on the current capability of the en route location, a modest improvement in infrastructure, a full improvement in infrastructure, and a theoretical best throughput possible" (Voight, 2005:3). The output identifies the en route bases with the highest throughput given a specified origin and destination pair. The results indicated that, "based on throughput capabilities…, U-Taphao, Bahrain, and Ascension Island are the three best potential en route airfields to consider for inclusion in the en route system" (Voight, 2005:49). This research allows USTRANSCOM to further refine the list of airfields for inclusion in the en route system.

Value Focused Thinking

"[The] reason for interest in any decision problem is the desire to avoid undesirable consequences and to achieve desirable ones. The relative desirability of consequences is a concept based on values" (Keeney, 1992:3). Thus, values should be the cornerstone of analyzing our decisions.

There are two approaches commonly used in Decision Analysis. The first and most widely used method is Alternative Focused Thinking (AFT). This method focuses on the apparent alternatives revealed without considering whether or not these alternatives will result in a desired outcome. Decision makers often use AFT because it is the easiest and quickest decision making process. However, AFT can result in choosing from a list of bad alternatives and missing an opportunity for success. A second method is Value Focused Thinking (VFT). This process focuses on the values that are important to the decision maker and therefore to the decision. "[W]hy … should [you] ever make the effort to choose an alternative rather than simply let whatever happens happen?" (Keeney, 1992:3). The answer is that the outcomes of alternatives may differ in terms of values. Thus, focusing on the values important to the decision will help eliminate the bad choices and bring the good choices to the forefront.

In the case of the ERS, many alternative bases and potential bases exist. What if the alternatives currently available do not meet the growing needs of the US military? Using AFT, Air Mobility Command (AMC) may analyze inadequate alternatives. Using VFT, alternatives can be developed and chosen based on AMC objectives. How is each base different and how can each base improve the current ERS? The answer to this question focuses on the values that make an en route base robust and effective. The alternatives can then be generated, evaluated, and ranked on how well they fit these values.

VFT is an important tool with several uses for decision problems. First, it assists in information collection. "Having a value hierarchy that specifies the important evaluation considerations in a decision can make it clear what … information is required" (Kirkwood, 1997:23). Second, VFT helps identify alternatives. When alternatives are not given, an explicit hierarchy provides a foundation for developing alternatives. Next, it promotes open and detailed communication. When multiple decision makers are involved, a value hierarchy aids in discussions while keeping in mind what evaluation considerations are important. Finally, VFT develops the model by which the alternatives are evaluated. The model, simple or complex, "will make clearer the relative desirability of various alternatives" (Kirkwood, 1997:23).

Keeney details ten steps that simplify and guide the VFT process (Keeney, 1992:55). These steps, shown in Figure 2.2, clearly outline the process to identify a favorable solution.

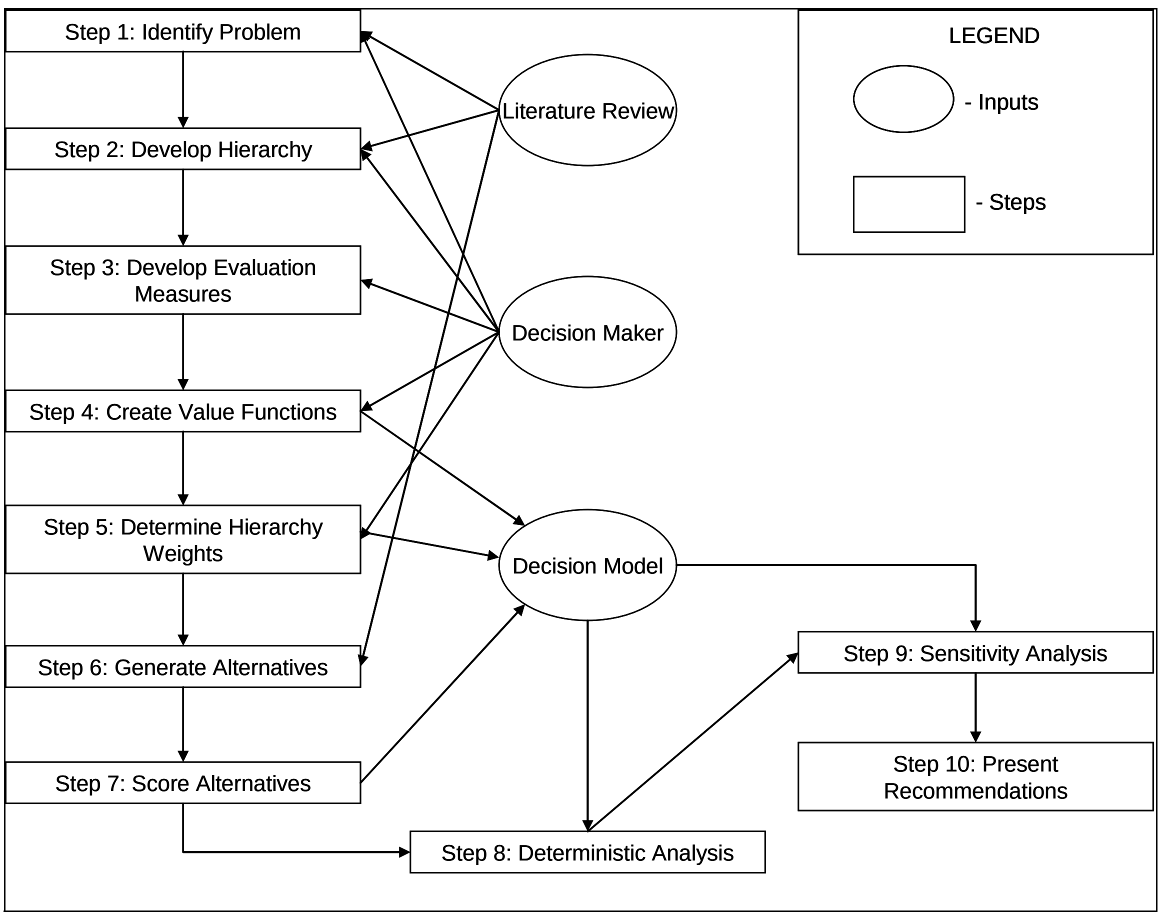


Figure 2.2. 10-Step Value Focused Thinking Process (Shoviak, 2001:63).

Summary

The ERS has become a focal point for USTRANSCOM and the regional commands over the last decade. The GWOT has created a world scenario never seen before that requires a stronger and more capable ERS. An in depth analysis of the ERS, its capabilities and weaknesses and how to improve it will allow USTRANSCOM to further strengthen the system to support future battles. This research delves into the factors that create an ideal en route base to illuminate the bases that can improve the ERS. This knowledge can enable decision makers to choose locations that could expand the ERS reach to the world. The following chapter details the VFT model developed to provide decision makers with greater insight into the ERS.

III. Methodology

This chapter discusses the methodology used in this research to create a detailed analysis of potential en route locations. Then, the data sources, scenario used and the output of the model are laid out.

En Route Location Selection Model

In order to evaluate potential en route locations, this research develops the En Route Location Selection (ERLS) Model to score and rank all prospective airfields. As Sere and Voight's work serve as a basis for this research, applicable data from their models is used as input to the ERLS model to ensure consistency. Specific information for each location was also gathered from Air Mobility Command and several Air Force websites to provide as much objective data as possible to reduce the subjectivity in the model's data.

Value Focused Thinking

Using a formal decision process offers the opportunity of an easily understood and defendable result. "Otherwise, it will be difficult to be sure that we have considered all the key aspects of the decision" (Kirkwood, 1997:3). Development of the model follows the 10-step process cited in Figure 2.2.

Step 1: Identify the Problem

AMC and USTRANSCOM identified a problem with the ERS after the DESERT STORM conflict. Airfields, not formally part of the ERS, were used during this time because the system itself was not able to sustain the increased operations. This showed that the ERS needed to be upgraded and expanded to meet the growing needs of the

United States military. USTRANSCOM focused on the problem and defined the decision question. What worldwide locations will best support the US military's missions, including wartime operations and humanitarian relief, by combining throughput capabilities and sustainment potential?

Step 2: Develop the Value Hierarchy

The value hierarchy detailing the important factors for an en route base was developed through previous research and interviews with subject matter experts (SME). The current research utilized two experienced Air Force rated pilots (one a C-17 pilot and the other a C-5 pilot) as SMEs (Miravite, A. and Schlegel, C.). As shown in Figure 3.1, the first tier in the hierarchy shows the two key concerns, throughput and sustainment, of the ERS. AMC needs to maximize throughput of the en route bases while ensuring these bases can be permanent facilities for continued use in the future. The second tier represents the six key areas that comprise throughput and sustainment. The six sub-objectives are En Route Diversions, Maximum on Ground Parking (MOG), Fuel, Host Nation Relations, Ground Transportation, and Geography. These six sub-objectives are then decomposed into the quantitative measures shown in Figure 3.1.

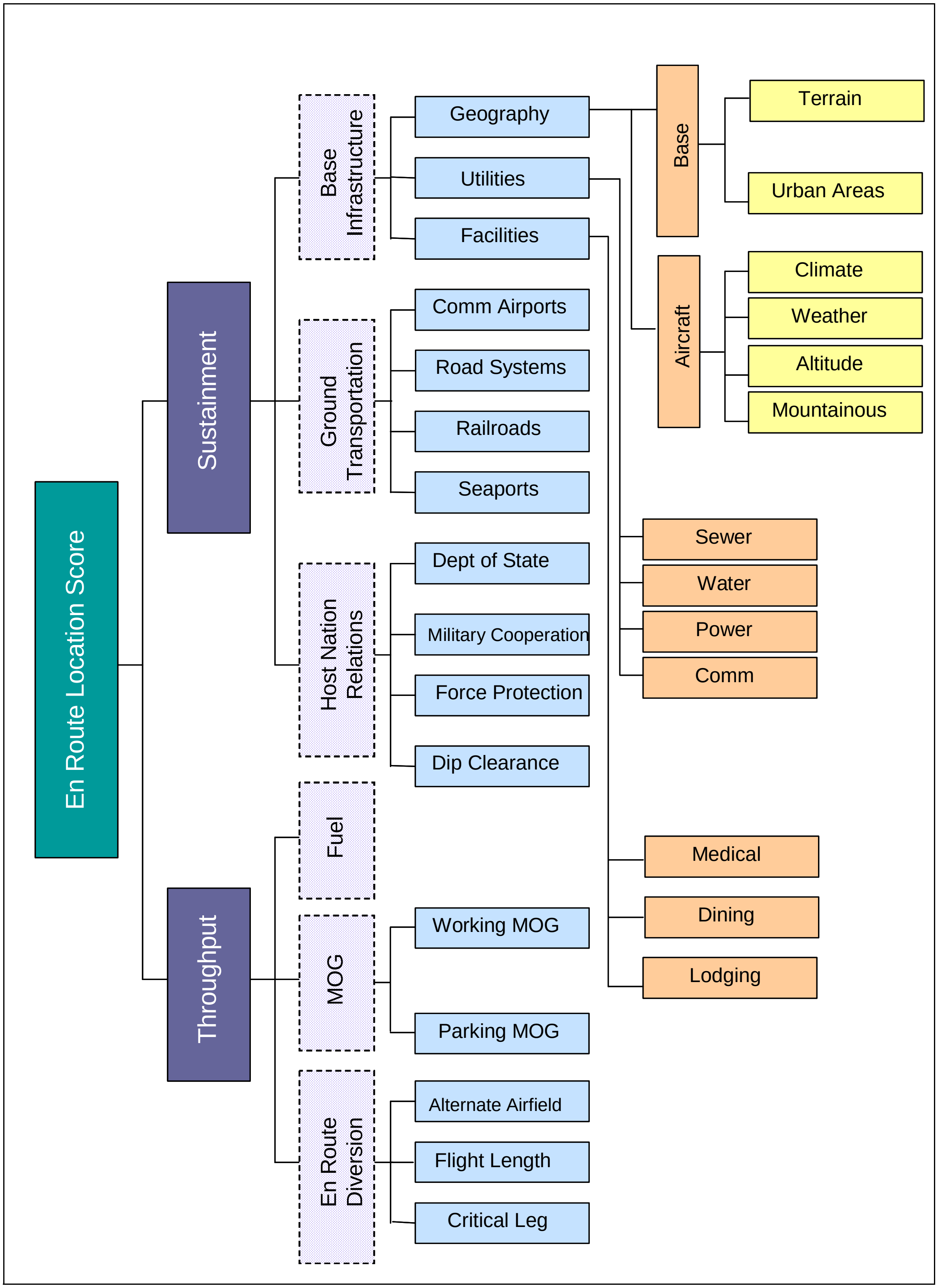


Figure 3.1. En Route Base Selection Value Hierarchy.

Several properties are desired in value hierarchies; “completeness, nonredundancy, independence, operability, and small size” (Kirkwood, 1997:16). Completeness is the requirement that each tier “adequately cover all concerns necessary to evaluate the overall objective.” In addition to completeness, the hierarchy must be nonredundant; no evaluation measures should overlap or count any aspect of the decision characteristics twice. Also, a change in the level of a measure should not affect the shape of any other measure’s associated value function; this preferential independence is required to formulate an additive value function. Operability calls for a model that is easily understood and operated by the end user. Finally, the hierarchy should be large enough to cover all key concerns of the initial decision problem but small enough to be easily understood and analyzed by the decision maker. Finally, each value function must be additive and the weights of each function must sum to one.

Step 3: Develop Evaluation Measures

The ERLS model is composed of two major attributes, Throughput and Sustainment, which are then decomposed into 27 measures. The values and measures for this research are explained in detail below.

Throughput is the amount of cargo that can transit a base in a given time period. Maximizing throughput allows more cargo to reach the destination and warfighter as quickly as possible. The factors analyzed under Throughput are; En Route Diversions, Maximum on Ground Parking (MOG), and Fuel Availability. En Route Diversions is decomposed into three measures; Critical Leg, Flight Length Delta, and Alternate Airfields. Critical Leg measures the longer leg of the two-leg flight, the distance from the origin to the en route or the distance from the en route to the destination. The Critical Leg can not exceed 3,500 nm as this is the maximum nominal range for a C-17 with a load of 45 short tons (McVicker, 2002). Any leg length exceeding this distance negatively affects the score of the corresponding airfield. There is ongoing research into the “optimal” distance for airlift aircraft carrying cargo however; 3,500 nm is the accepted AMC planning distance and it is used in this research. Below is an example of Critical Leg, Figure 3.2.

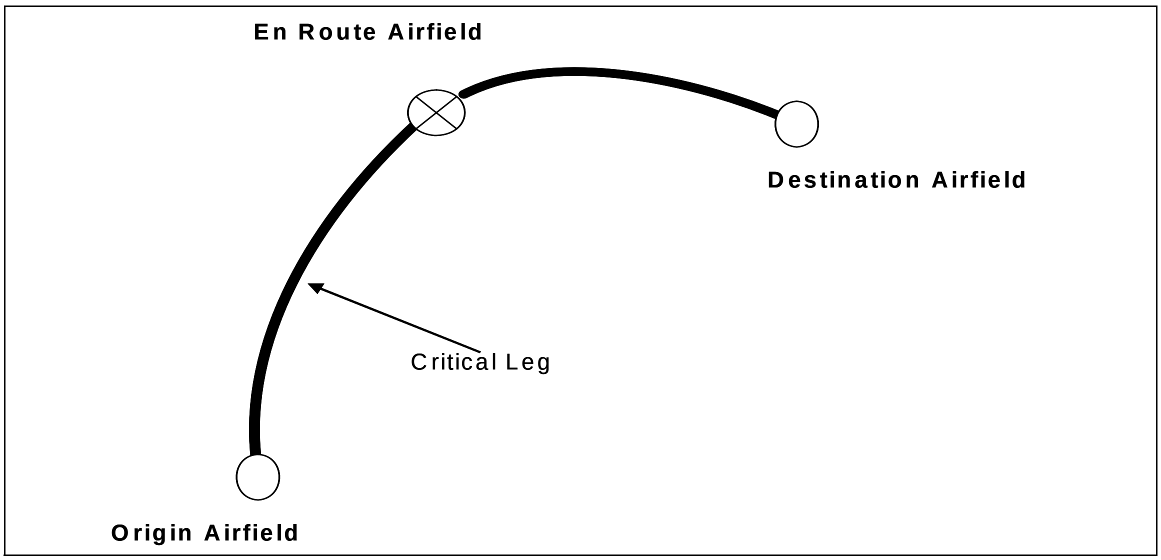


Figure 3.2. Critical Leg.

Flight Length Delta is the difference between the length of the direct flight from origin to destination and the length of the flight through the proposed en route base. A large delta will penalize the potential en route airfield because of the increased use of fuel and flight hours. The goal is to find an en route with a flight path as close to the direct flight path as is feasible. Flight Length Delta assumes that the most direct flight path from origin to destination is an ideal flight path. Distances are calculated using a great circle route, the shortest route between any two points on the globe (Swartz, 2005).

Alternate Airfields counts the number of airfields within 500 nm of the en route base. This mileage is determined from AFI 11-2C-17V3 and AFI 11-2C-5V3. These regulations specify the "use [of 75 minutes] holding fuel when flying to an island or remote destination" (AFI 11-2C-17V3:6.20). Holding fuel is the amount of fuel aircrew plan for in case of the need to fly in the holding pattern at the en route base. One hour and fifteen minutes of flight time equates to approximately 500nm. These bases must also have a runway on which a C-5 or C-17 can land in case of diversions due to weather, maintenance or other reasons at the en route location. All airfields evaluated in this research are assumed to conduct 24-hour operations. The alternate airfields for each potential en route are shown in Appendix A.

Maximum on Ground Parking (MOG) consists of Working MOG and Parking MOG. Working MOG counts the number of C-5s and C-17s that can be serviced simultaneously, i.e., the number of wide-body aircraft that can be on- or off-loaded, refueled, and receive maintenance. Parking MOG counts the number of wide-body aircraft that can be parked, not receiving service, at an airfield at one time. These elements affect the throughput of a potential base by limiting the number of aircraft able to utilize an airfield on a given day. Parking and Working MOG are calculated based on C-17s only with the assumption that three C-17s equal one C-5.

Fuel Availability measures the amount of fuel available at a base for airlift aircraft. This is an essential factor in en route location selection because throughput is limited by the number of aircraft that can receive fuel in order to continue their missions. Fuel is assumed to be available at the base without concern for mode of delivery such as truck or pipeline. These measures are detailed in Table 3.1.

Table 3.1. Throughput Measures.

Measure	Discrete/ Continuous	Units of Measurement	Range	Levels and Values
Critical Leg	Continuous	Nm[1]	[0,3,500 nm]	V(3500) = 1.0 V(3250) = 0.5 V(0) = 0.0 V(>3500) = 0.0
Delta Flight Length	Continuous	Nm	[0,2,500 nm]	V(0) = 1.0 V(800) = 0.5 V(2500) = 0.0
Alternate Airfields	Discrete	Count	[0,200]	V(200) = 1.0 V(6) = 0.5 V(0) = 0.0
Working MOG[2]	Discrete	Count	[0,10]	V(10) = 1.0 V(6) = 0.5 V(0) = 0.0
Parking MOG	Discrete	Count	[0,40]	V(40) = 1.0 V(24) = 0.5 V(0) =0.0
Fuel	Continuous	Gallons	[0,3.5 million]	V(3.5 mill gals) = 1.0 V(2.5 mill gals) = 0.5 V(0 gals) = 0.0
Notes: 1. Nm: Nautical Miles. 2. MOG: Maximum On Ground Parking.				

The second major attribute, Sustainment, is the ability of a location to maintain an en route airfield over an extended period of time. This is decomposed into three sub-objectives; Host Nation Relations, Ground Transportation, and Base Infrastructure; which affect the permanency and usefulness of a base. If any of these factors change, the en route base may be required to decrease or cease air operations.

Host Nation Relations are the factors that affect a nation’s ability to host an en route airbase. The relationship of the United States with any nation is complicated and highly variable. This model attempts to account for these factors completely and succinctly via the measures Diplomatic Clearance, Military Cooperation, Force

Protection, and Department of State. These factors indicate the type of relationship between the US and the host nation and the potential for a permanent military facility.

Diplomatic Clearance is the accessibility of host nation's land and airspace for US military missions. Four levels are defined for this measure. Blanket Clearance indicates unlimited access to the nation's airspace and land. Limited Clearance is the ability of the US to use a nation's air and land for US military missions for an extended period of time, such as OPERATION ENDURING FREEDOM. Mission-by-Mission Clearance is the ability of the US to use a nation's land or air space only upon request for a specific mission. No clearance, or None, means the US is not able to use the nation's land or air space for any military missions, excluding operations such as humanitarian relief. No clearance requires US military missions fly around the country's borders.

Military Cooperation is the relationship between the US military and the host nation military. The criteria for military cooperation are 1) common military organization membership, 2) conduct of annual joint multinational exercises, and 3) maintenance of troop exchange programs. Membership in common military organizations, such as NATO, indicates support of common international objectives. Conduct of annual joint multinational exercises indicates common understanding of military tactics and equipment and the willingness to cooperate in future military operations. Maintenance of troop exchange programs indicates mutual trust and freedom of communication between the militaries. The host nation is scored based on the number of criteria met.

Force Protection is the amount of security and medical personnel the US must provide for a mission through the host nation. This is measured as Complete, Moderate, and Minimal. Complete force protection means the US must provide the preponderance of security forces, for its missions through the host nation, for protection against terrorist attacks and other criminal threats. The US must also provide medical personnel to protect against medical concerns such as cholera and malaria. Moderate force protection means the US provides a small group of security and medical personnel due to the minor threat of terrorist, criminal, or medical threats, or, when the security responsibility is shared between the US and the host nation militaries independent of the level of terrorist, criminal, and medical threat. Minimal force protection means there is a low threat of terrorist attack, criminal activity, or disease, or the host nation provides the preponderance of indigenous forces for security of US missions.

Department of State is the US perception of our relationship with a potential host nation. The criteria for this measure are 1) common global political goals, 2) common global military goals, 3) common humanitarian goals, 4) similar government, and 5) similar belief system. Common global political goals show the countries agree on politics and open talks with nations of differing politics and desire common political changes around the world. Common global military goals suggest the host nation supports US military objectives such as deterring communism and violent dictatorship. Common humanitarian goals indicate the host nation supports the US objective of equal rights and the ethical treatment of persons in all nations of all races and religious preferences. A similar government is that which is elected, by free choice, by the indigenous people. Finally, similar belief system is a reflection of whether or not a country has similar cultural ideals and principles. A host nation is scored on the number of criteria met. The measures are shown in Table 3.2.

Table 3.2. Sustainment/Host Nation Relations Measures.

Measure	Discrete/ Continuous	Units of Measurement	Levels and Values
Diplomatic Clearance	Discrete	N/A	V(Blanket) = 1.0 V(Limited) = 0.8 V(Mission) = 0.6 V(None) = 0.0
Force Protection	Discrete	N/A	V(Minimal) = 1.0 V(Moderate) = 0.7 V(Complete) = 0.0
Military Cooperation	Discrete	N/A	V(Excellent) = 1.0 V(Good) = 0.8 V(Fair) = 0.5 V(Poor) = 0.0
Department of State	Discrete	N/A	V(Excellent) = 1.0 V(Good) = 0.6 V(Satisfactory) = 0.3 V(Poor) = 0.1 V(Unacceptable) = 0.0

Ground Transportation is the ability to move cargo from a particular en route airfield to a designated destination, including accessibility, maintainability, and throughput capabilities of select modes of transportation. The modes of transportation evaluated are Railroads, Roads, Seaports, and Commercial Airports. Railroad measures the distance from the en route airfield to the nearest railhead or rail cargo on- and off-load point. Road System measures the distance to the nearest paved, divided four lane highway, or equivalent, from the en route base. Seaport measures the distance from the en route airfield to the nearest seaport. Commercial Airport measures the distance from the airfield to the nearest civilian airport. Each of these measures indicates the ability to move cargo through a nation for continued mission support. These measures are shown in Table 3.3 below.

Table 3.3. Sustainment/Ground Transportation Measures.

Measures	Discrete/ Continuous	Range (miles)	Levels and Values
Railroads	Continuous	[0,50]	V(0m) = 1.0 V(10m) = 0.5 V(50m) = 0.0
Road System	Continuous	[0,100]	V(0) = 1.0 V(5m) = 0.9 V(20m) = 0.5 V(100m) = 0.0
Seaports	Continuous	[0,500]	V(0) = 1.0 V(10m) = 0.9 V(50m) = 0.6 V(100m) = 0.1 V(500) = 0.0
Commercial Airports	Continuous	[0,200]	V(0) = 1.0 V(10m) = 0.9 V(50m) = 0.5 V(100m) = 0.2 V(200) = 0.0

Base Infrastructure assesses the usability and maintainability of an en route base. This is broken down into three measures; Facilities, Utilities, and Geography.

Facilities gauge the existing infrastructure available to support basic human needs. The measure is divided into Lodging, Dining, and Medical.

Lodging is the availability of billeting or hotels at the en route base or in the local area. Given the local threat level, are adequate facilities available on or off base? This is measured as Adequate, Partial, or Inadequate. For example, if the lodging on base is adequate, regardless of the local threat level, the lodging is deemed adequate. If the local threat level is low, the lodging facilities on base are limited and the lodging off base is expensive, the lodging is judged as partially sufficient. If the local threat level is high and there exists only limited lodging facilities on base, the lodging is deemed inadequate.

Dining is the availability of eating facilities at the en route base or in the local area. Similar to lodging, given the local threat level, are adequate dining facilities available on base or in the local area? This is measured as Adequate, Partial, or Inadequate.

Note that, Lodging, Dining, and Force Protection measures were defined in such a way to maintain preferential independence between them. That is, the decision maker's preference for the levels of Lodging does not depend on the level of Dining or Force Protection. For example, adequate Lodging is preferred to no Lodging for any combination of levels of Dining and Force Protection.

Medical is the availability of permanent medical facilities and staff at the en route location. This is a binary measure indicating the accessibility of health and wound care of troops at the en route location.

The availability of existing Utility infrastructure to support the en route base and its mission is measured through Communications, Power, Potable Water, and Sewer.

Communications assesses the level of communications infrastructure available at the en route location. This is measured as one of four categories, Robust, Adequate, Inadequate, or None. Robust indicates all avenues of communication such as phone, internet, data transfer, and satellite are available and the infrastructure is suitable for potential base expansion. Adequate signifies all avenues of communication are available but the infrastructure has minimal expansion capability to meet future growth demands. Inadequate shows only rudimentary infrastructure is available and upgrades must be made before the system can be satisfactorily used. None shows no communication system exists and must be built from the ground up.

Power indicates the level of infrastructure available for power needs at an en route location. In the same fashion as Communication, the four levels are Robust, Adequate, Inadequate, or None. Potable Water considers the availability of infrastructure to supply water for drinking, bathing, and washing. This is measured as Robust, Adequate, Inadequate, or None. Sewer evaluates the infrastructure available to provide for sewage treatment and removal and is measured as Robust, Adequate, Inadequate, or None.

Geography focuses on features of the land surrounding the airfield that affect the aircraft or the base. Traits affecting the aircraft pertain to the aircraft performance and safety. Features affecting the base relate to base expansion.

Geographic features affecting aircraft performance and safety are Mountains, Altitude, Weather, and Climate. Mountains identify whether or not the base is closely surrounded by mountains that effect aircraft take off and landing parameters. Changes in flight path (limited glide path), unsafe climb parameters, and decrease in takeoff weight affect flight safety and efficiency. Altitude denotes whether or not the base is located at an altitude that negatively affects allowable takeoff weight, affecting cargo carrying ability and decreasing mission effectiveness. Climate indicates if temperatures at the airfield reach extremes, more than 20 percent of the year, which affect aircraft takeoff parameters. Extreme temperatures can reduce allowable cargo load and alter aircraft safety measures. Altitude and climate assume a C-17 cargo load of 45 short tons. Weather reflects the frequency of adverse weather events, such as hurricanes or sandstorms, which occur at the en route location. These weather events can close down air operations for extended periods of time, causing significant cargo delays.

Geographic features affecting the base are related to the growth and potential expansion of the base. Urban Areas, or urban encroachment, identifies whether or not the base is limited in growth potential by the progression of surrounding cities. Terrain measures the restrictions on base growth by local features such as swamps, waterways, and mountains. These measures are detailed in Table 3.4.

Table 3.4 Sustainment/Base Infrastructure.

Measure	Discrete/ Continuous	Units of Measurement	Levels and Values
Lodging	Discrete	Count	V(Adequate) = 1.0 V(Partial) = 0.8 V(Inadequate) = 0.0
Dining	Discrete	Count	V(Adequate) = 1.0 V(Partial) = 0.65 V(Inadequate) = 0.0
Medical	Discrete	Binary	V(Yes) = 1.0 V(No) = 0.0
Communications	Discrete	Count	V(Robust) = 1.0 V(Adequate) = 0.9 V(Inadequate) = 0.3 V(None) = 0.0
Power	Discrete	Count	V(Robust) = 1.0 V(Adequate) = 0.9 V(Inadequate) = 0.2 V(None) = 0.0
Potable Water	Discrete	Count	V(Robust) = 1.0 V(Adequate) = 0.9 V(Inadequate) = 0.55 V(None) = 0.0
Sewer	Discrete	Count	V(Robust) = 1.0 V(Adequate) = 0.9 V(Inadequate) = 0.55 V(None) = 0.0
Mountainous	Discrete	Binary	V(No) = 1.0 V(Yes) = 0.0
Altitude	Discrete	Binary	V(No) = 1.0 V(Yes) = 0.0
Weather	Discrete	Count	V(Minimal) = 1.0 V(Average) = 0.35 V(Heavy) = 0.0
Climate	Discrete	Binary	V(No) = 1.0 V(Yes) = 0.0
Urban Areas	Discrete	Binary	V(No) = 1.0 V(Yes) = 0.0
Terrain	Discrete	Binary	V(No) = 1.0 V(Yes) = 0.0

Step 4: Create Value Functions

Each measure requires a single dimensional value function (SDVF) to convert the x-axis measures to y-axis values. An interview document was made to guide the analyst and decision maker or SME through the SDVF development process. This document explains the purpose of SDVFs and asks the SME a series of questions to create the SDVF. The technique used in this research, for continuous measures, asks the SME to determine the midpoint of a specific measure and repeats this procedure until midpoints are determined (Kirkwood, 1997:64). For discrete measures, the SME is asked to determine the value, scaled between zero and one, for each level of the measure. The resulting SDVFs are shown Appendix B.

Step 5: Determine Hierarchy Weights

Each measure in the hierarchy is not of equal importance. Weighing each measure allows the decision maker to indicate the relative level of importance of each measure to the overall decision problem. The SME and decision makers must again be interviewed to determine the individual weights. The local and global weights for the hierarchy can be seen in Appendix C.

Step 6: Generate Alternatives

The alternatives for the en route decision problem consist of en route bases currently in the ERS and other airfields around the world. The existing bases are evaluated to determine their contribution to the current ERS and as a comparison for the potential airfields. The remaining airfields are evaluated to reveal any favorable additions to the ERS. The bases are evaluated on how well each scores on the developed measures. It should be noted that making no changes in the ERS is also an alternative.

Step 7: Scoring Alternatives

The alternatives being scored in this research include the 25 potential locations evaluated in the works of Sere and Voight plus the current European and Pacific en route bases. The majority of the data collected is objective and does not require the interpretation of the analyst or decision maker. However, Force Protection, Department of State, Military Cooperation, Lodging, and Dining require the experience and judgment of a SME. For these measures, the SME determined the value of each measure for each alternative before proceeding to the next measure. This allowed the SME to maintain consistent scoring throughout the process. Also, the SME were not given access to the value functions previously developed to avoid bias.

Steps 8, 9; Deterministic Analysis, and Sensitivity Analysis; are discussed Chapter IV. Step 10, Recommendations, are presented in Chapter V.

Data Sources

In order to rate each alternative, this research developed a value hierarchy with an additive value function to calculate the overall worth of a base to the ERS. The airfields examined in Sere's research are the ones used here. Specific data about the airfields was gathered to provide an accurate evaluation of each base. The distance measures are calculated using the internet site, Great Circle Mapper (Swartz, 2005). Fuel data was gathered from the Capabilities-Based Logistics Planner (Air Force Studies and Analyses, 2004). Diplomatic relations, Department of State, Force Protection, and Lodging and Dining adequacy are determined through decision maker interviews. Ground Transportation data was collected from the CIA Factbook (Central Intelligence Agency, 2005) and the US Department of State website (US Department of State, 2005). Weather and Temperature information is retrieved from the World Climate website (Hoare, 2006). The remaining data for this research is drawn from reports compiled by Tanker Airlift Control Element (TALCE) (Air Mobility Command, 2005). TALCE is

> a mobile command and control organization deployed to support strategic and theater air mobility operations at fixed, en route, and deployed locations where air mobility operational support is nonexistent or insufficient. [TALCE] provides on-site management of air mobility airfield operations to include command and control, communications, aerial port services, maintenance, security, transportation, weather, intelligence, and other support functions, as necessary. [TALCE] is composed of mission support elements from various units and deploys in support of peacetime, contingency, and emergency relief operations on both planned and 'no notice' basis. (DOD JP 1-02)

Scenario Setup

In order to assess and rank airfield performance, a set of origins, destinations, and en routes are constructed. This research focuses on one-stop trips; flights that only need one stop for fuel, maintenance, and crew rest to reach the destination. The continental US (CONUS) origin airfields include Dover AFB, Delaware; Charleston AFB, South Carolina; Travis AFB, California; and McChord AFB, Washington. These bases have been selected because they are already established airlift origin bases. Since many destinations are too far to be reached from the US with only one stop, several European and Pacific bases were selected as origins including Andersen AB, Guam; Elmendorf AFB, Alaska; Hickam AFB, Hawaii; Incirlik AB, Turkey; Lajes AB, Azores, Portugal; Ramstein AB, Germany; Naval Air Station (NAS) Rota , Spain; Yokota AB, Japan.

Next, a list of destinations was created. Crime and terrorism can break out in any area of the world so destinations were chosen in diverse areas. Specific locations were selected in eight geographic areas: Central Asia, Southwest Asia, Southeast Asia, Southern Asia, Northeastern Asia, Southern Africa, Western Africa, and South America. The specific destinations are Lahore, Pakistan; Baghdad International, Iraq; Dili, Indonesia; Gao, India; Seoul AB, South Korea; Waterkloof, South Africa; Monrovia, Liberia; and Bahia Blanca, Argentina, respectively. Figure 3.3 shows a map of the origins and destinations considered in this research.

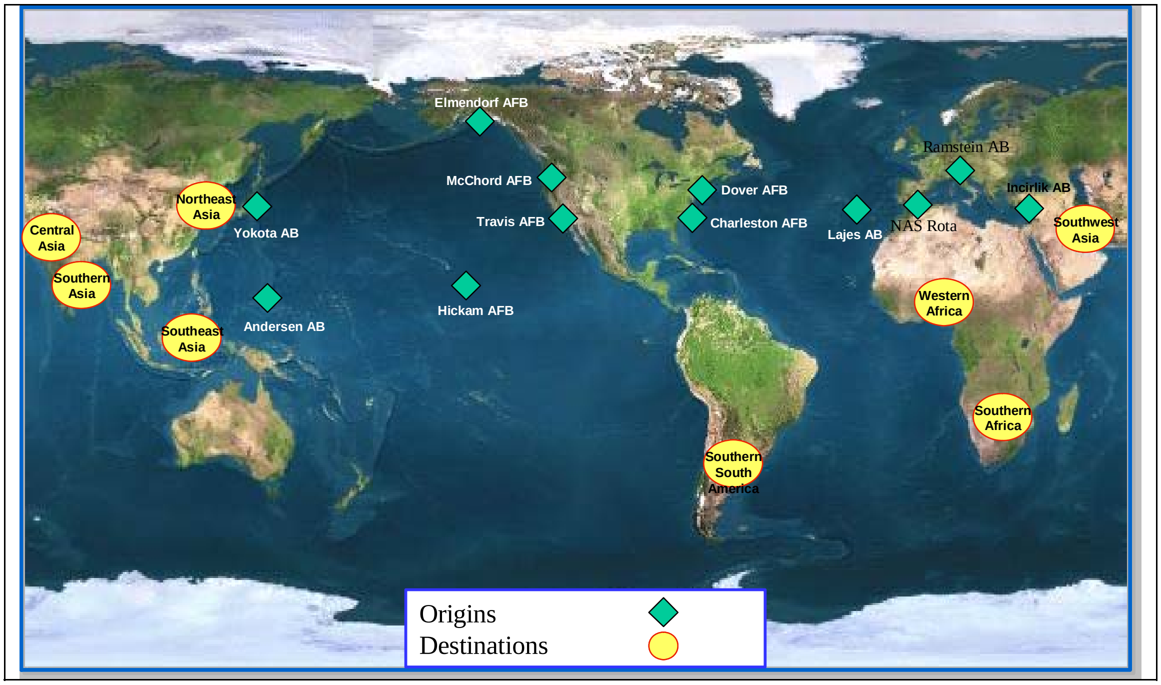


Figure 3.3. Origins and Destinations.

Finally, the en route airfields were chosen. For consistency, the bases evaluated in this research are drawn from Sere (Sere, 2005:21). Figure 3.4 shows the potential en route airfields and the existing en route bases in Europe and the Pacific assessed by ERLS.

Figure 3.4. En Routes Bases (Sere, 2004:24).

Model output

This model looks at all the combinations of the twelve origin, eight destination, and 41 en route bases. Each en route base is evaluated on how well it meets each of the measures and then for each origin/destination pair, the en route bases are ranked from highest to lowest score. This ranking allows the decision maker to identify the bases that are potential additions to the current ERS.

The results of the model developed in Chapter III are detailed in Chapter IV. This output shows the en route airfields that are the best airfields to create a global ERS.

IV. Results and Analysis

Introduction

The ERLS model results in a rank ordering of 41 potential airfields for every combination of twelve origins and eight destinations. This chapter reviews these results showing what en route airfields rank in the top three for each origin/destination pair. Next, these results are compared to results of previous research to find any significant changes or variations. Finally, several experiments are conducted to show sensitivity to changes in preference structure and to methods of determining the score for a destination. The rank orderings for each destination are shown in Appendix D and the graphic results of the ERLS model is shown in Appendix E.

Results

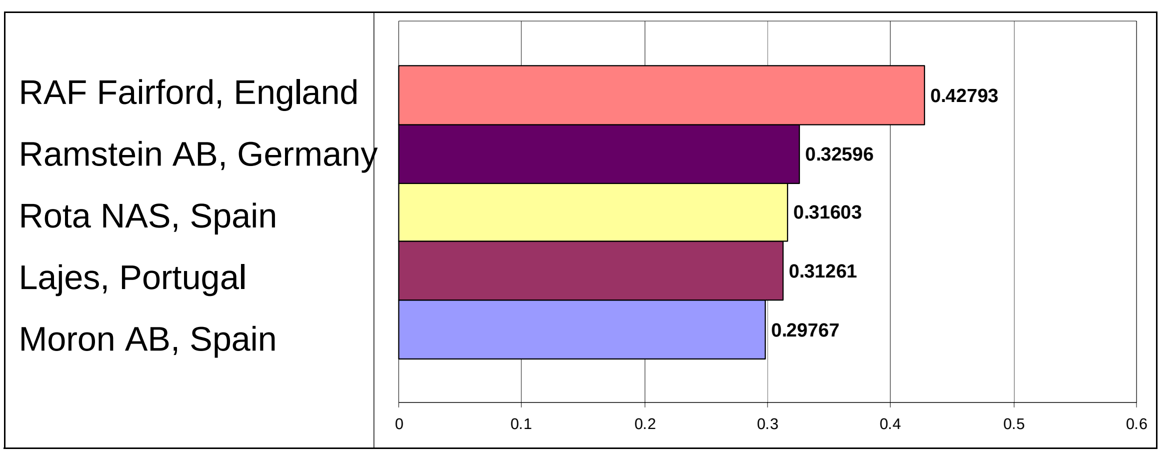
This research evaluates twelve origins, 41 en route airfields, and eight destinations. To determine the top five en route bases for a single destination, the mean score for each en route airfield is calculated. These are then compared to rank the en route airfields from most preferred to least preferred. Figure 4.1 illustrates the 41 en route airfields evaluated in the current model.

Figure 4.1. En Routes Bases (Sere, 2004:24).

Destination 1: Southwest Asia (Baghdad International, Iraq)

Baghdad International, Iraq is the representative location in Southwest Asia. The top five en route bases for travel to Baghdad International, Iraq are shown in the Table 4.1 below.

Table 4.1. Top Five En Route Bases for Southwest Asia.

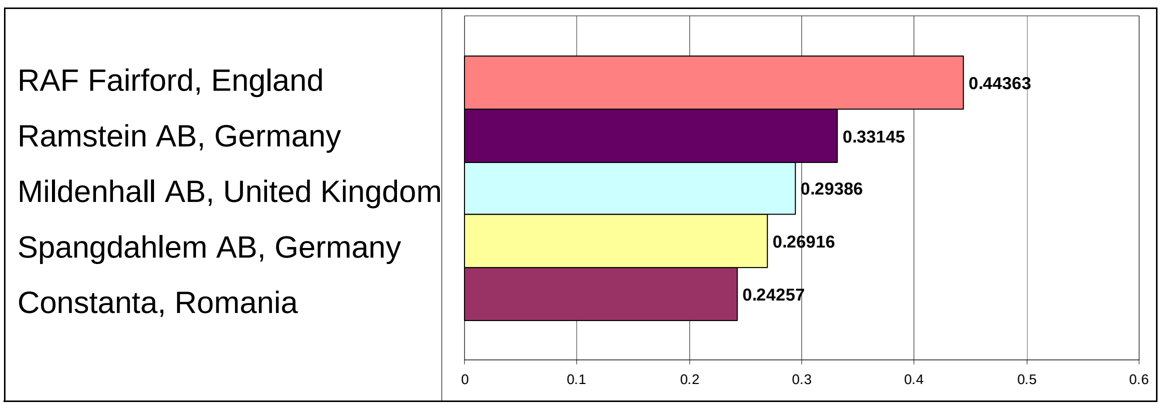


The ERS was built to meet Cold War requirements including Southwest Asia, thus the results for Baghdad International, Iraq are expected. These results indicate that the current ERS bases are the most preferred bases for destinations in Southwest Asia. RAF Fairford, Germany is the most preferred en route base for Baghdad International, Iraq.

Destination 2: Central Asia (Lahore, Pakistan)

Lahore, Pakistan is the representative location in Central Asia. The top five ERLS model results for Lahore, Pakistan are shown in Table 4.2.

Table 4.2. Top Five En Route Bases for Central Asia.

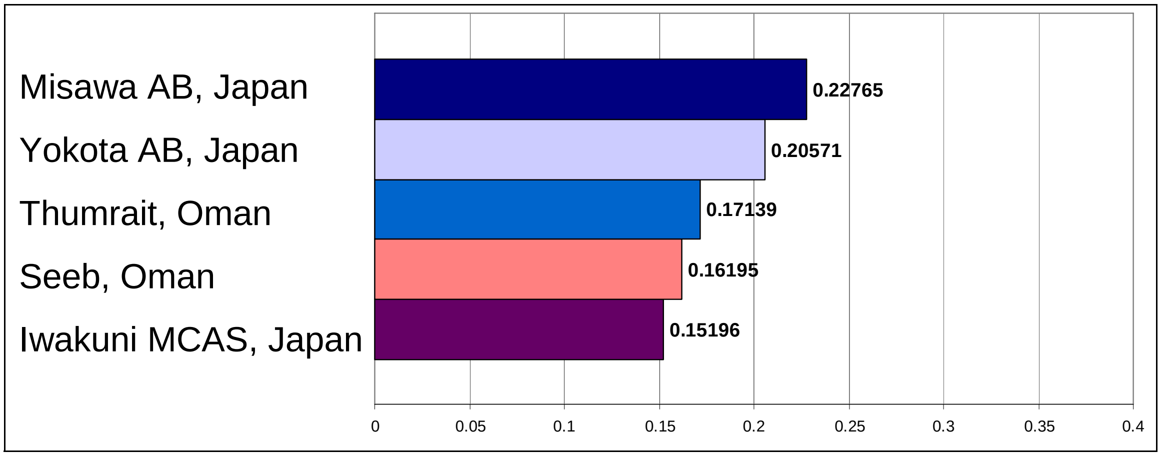


As seen, Central Asia is accessible through several bases currently in the ERS. This indicates new en route bases are not necessary for Central Asia. However, Constanta, Romania ranked highly and is not currently part of the ERS. This indicates Constanta, Romania would be a potential en route airfield if one is desired.

Destination 3: Southeast Asia (Dili, Indonesia)

Dili, Indonesia is the representative location in Southeast Asia. The top five en route bases to Southeast Asia are shown in Table 4.3.

Table 4.3. Top Five En Route Bases to Southeast Asia.

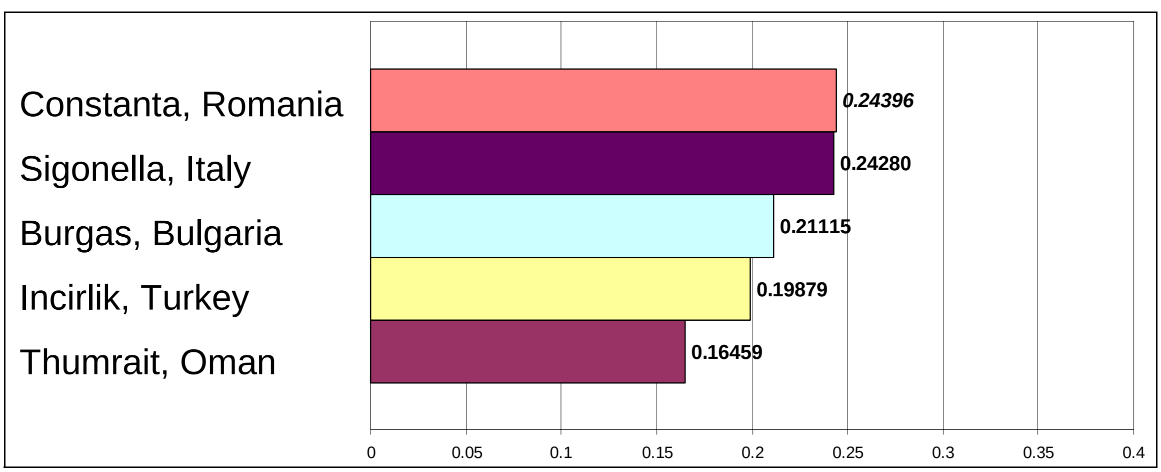


As shown, the Japan based airfields, which are part of the ERS, provide access to Southeast Asia. Three of the top five bases are located in Japan imposing dependence on relations with a single country. Oman based airfields could diversify the ERS and remove unnecessary dependence on host nations.

Destination 4. Southern Asia (Gao, India)

Gao, India is the representative location in Southern Asia. The top five en route bases for Gao, India are shown in Table 4.4 below.

Table 4.4. Top Five En Route Bases to Southern Asia.

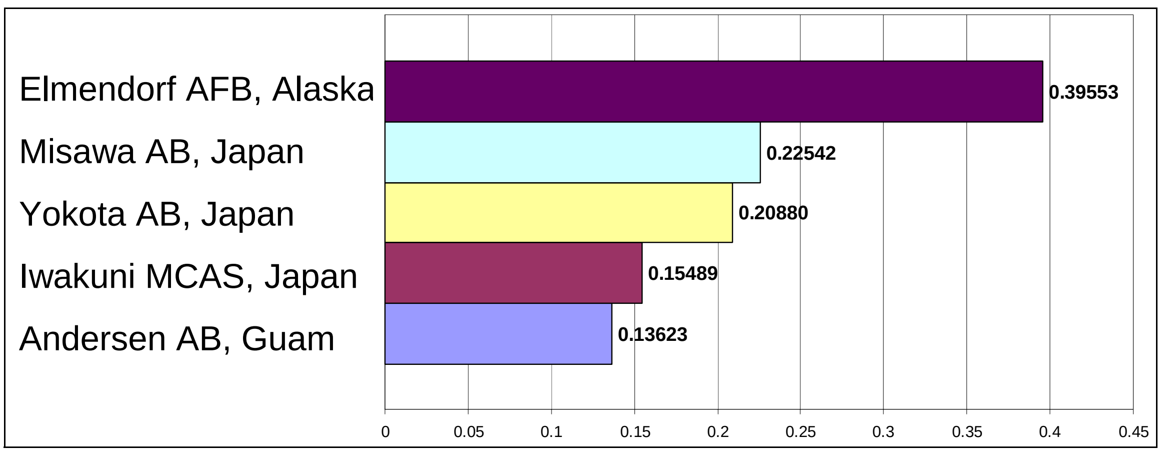


The airfields shown above are not part of the current ERS. This indicates that Southern Asia is not readily accessible and operations to this region could be difficult to support. Since India is in an area with an unpredictable political climate, an en route airfield could be beneficial. Constanta, Romania is the most preferred en route airfield for Southern Asia.

Destination 5. Northeastern Asia (Seoul AB, Republic of Korea)

Seoul AB, Republic of Korea is the representative location in Northeastern Asia. Table 4.5 shows the top five en route airfields for Northeastern Asia.

Table 4.5. Top Five En Route Bases to Northeastern Asia.

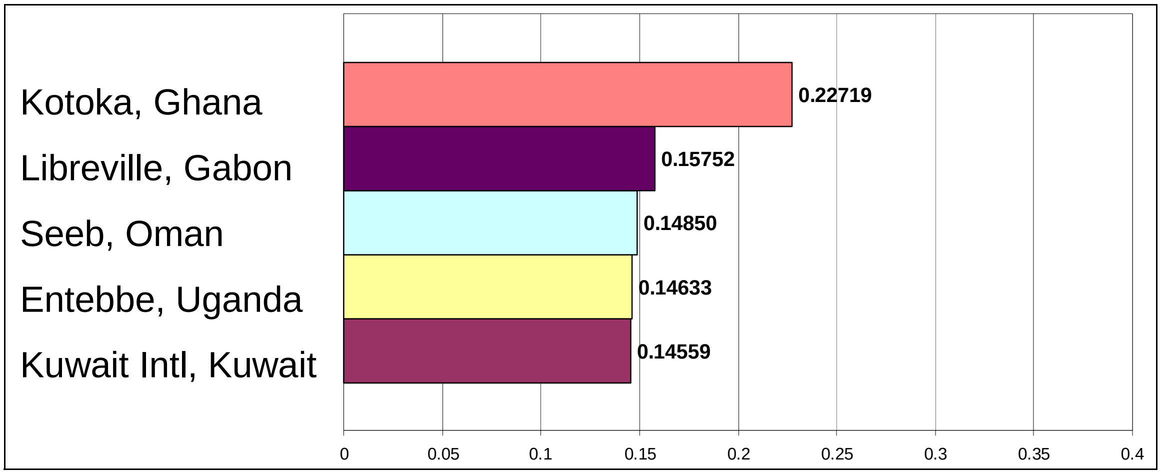


Northeastern Asia was also a focus during the Cold War. Thus, the ERS was developed to provide sustained mission support to the Korean Peninsula. The top five airfields for Seoul, Republic of Korea are expected results and illustrate the effectiveness of the ERS in meeting the previous requirements.

Destination 6. Southern Africa (Waterkloof, South Africa)

Waterkloof, South Africa is the representative location in Southern Africa. Table 4.6 shows the top five airfields for travel to Waterkloof, South Africa.

Table 4.6. Top Five En Route Bases to Southern Africa.

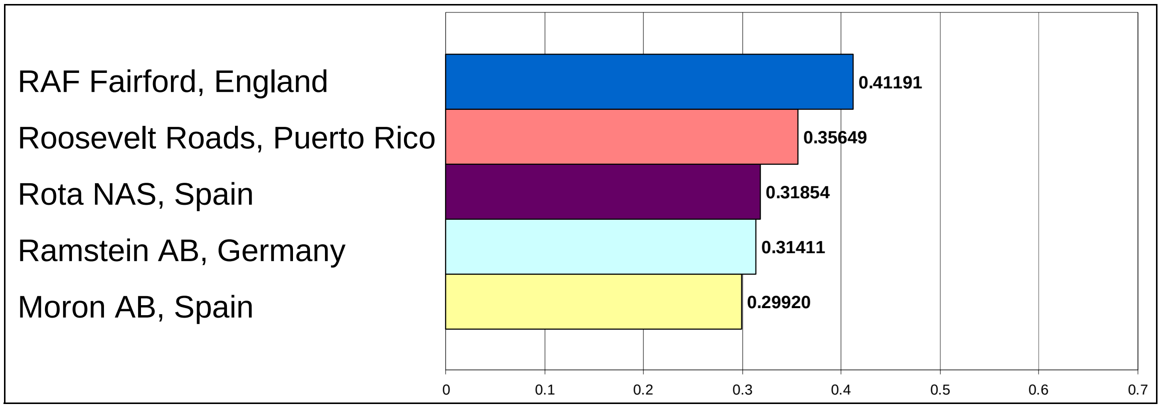


As for Southern Asia, the results for Southern Africa do not include any current ERS bases in the top five. This could create difficulty in maintaining operations to Southern Africa if such is required. Kotoka, Ghana is the most preferred en route base for Waterkloof, South Africa and could prove beneficial if operations to this area are needed.

Destination 7. Western Africa (Monrovia, Liberia)

Monrovia, Liberia is the representative location in Western Africa. Table 4.7 shows the top five en route airfields as indicated by the ERLS model for Monrovia, Liberia.

Table 4.7. Top Five En Route Bases to Western Africa.

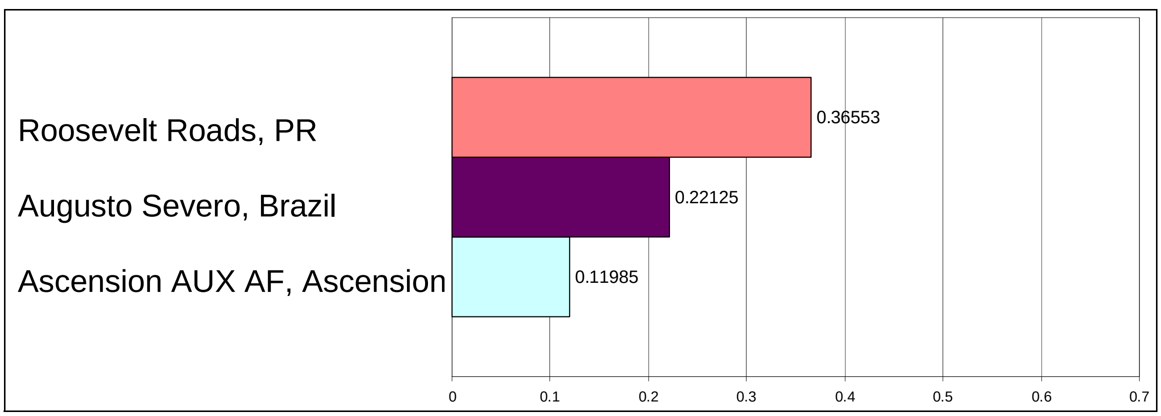


The ERLS results show several airfields, currently part of the ERS, which provide access to Western Africa. However, Roosevelt Roads, Puerto Rico is not part of the ERS and ranks high in the ordering. This indicates Roosevelt Roads is a potential en route airfield for addition to the ERS.

Destination 8. Southern South America (Bahia Blanca, Argentina)

Bahia Blanca, Argentina is the representative location in Southern South America. Table 4.8 shows top three en route airfields to Bahia Blanca, Argentina.

Table 4.8. Top Three En Route Bases to Southern South America.



Only three bases are shown for South America because these are the only three airfields evaluated in the research that are feasible solutions. The remaining airfields have a critical leg that is too long to fly without in-air refueling. South America is also an area with a changing political climate and thus should be considered for the future possibility of required military operations.

The ERLS model shows several geographic areas that are not accessible through the ERS. Southern Asia, South Africa, and Southern South America are areas with no current en route base ranked in the top five. The analysis also shows no bases currently in the ERS rank in the top ten for these three areas. Thus; India, South Africa, and Argentina are areas with a credible need for an en route airfield. The remaining geographic regions each have at least two ERS airfields which provide access to the region. This initial model suggests en route airfields accessing Southern Asia, South Africa, and Southern South America would be beneficial to creating a global ERS. Five bases; Ascension AUX AF, Ascension; Seeb, Oman; Kuwait International, Kuwait; Bahrain International, Bahrain; and Ali Al Salem, Kuwait; occur more times than the remaining potential en route bases for access to the India, South Africa, and Argentina. However, any one of these bases opens access to only two destinations but not all three. To access all eight regions evaluated in this research at least two en route bases would need to be developed.

Previous Research Results

Previous research also developed a top ten list of potential en route airfields to the eight geographical regions evaluated. The similarities and differences between the models were assessed to determine any short falls in the current model.

Destination 1: Southwest Asia (Baghdad International, Iraq)

Table 4.9 below shows a comparison between the original model and the previous model for the top ten en route airfields for Baghdad International, Iraq.

Table 4.9. Comparison of Top Ten En Route Bases for Southwest Asia.

Current Model Results	Previous Model Results
RAF Fairford, England	Ramstein AB, Germany
Ramstein AB, Germany	Spangdahlem AB, Germany
Rota NAS, Spain	Incirlik AB, Turkey
Lajes, Spain	Constanta, Romania
Moron AB, Spain	Burgas, Bulgaria
Mildenhall AB, United Kingdom	Bahrain International, Bahrain
Spangdahlem AB, Germany	Sigonella, Italy
Constanta, Romania	Seeb, Oman
Sigonella, Italy	Kuwait International, Kuwait
Kotoka, Ghana	Mildenhall AB, United Kingdom

This comparison shows several similar preferred options suggesting the current model is correctly assessing the potential airfields. The rank ordering for these bases differs, signifying the detail of the current model and the decision maker expertise affects the list of preferred en route bases. There are also several potential airfields that differ. The detailed model and use of expert knowledge allows the decision maker to view potential airfields that meet the needs and requirements of the US Air Force.

Destination 2: Central Asia (Lahore, Pakistan)

Table 4.10 below shows a comparison between the original model and the previous model for the top ten en route airfields for Lahore, Pakistan.

Table 4.10. Comparison of Top Ten En Route Bases for Central Asia.

Current Model Results	Previous Model Results
RAF Fairford, England	Seeb International, Oman
Ramstein AB, Germany	Incirlik AB, Turkey
Mildenhall AB, United Kingdom	Bahrain International, Bahrain
Spangdahlem AB, Germany	Constanta, Romania
Constanta, Romania	Burgas, Bulgaria
Sigonella AB, Italy	Kuwait International, Kuwait
Misawa AB, Japan	Ramstein AB, Germany
Yokota AB, Japan	Spangdahlem AB, Germany
Burgas, Bulgaria	Thumrait, Oman
Incirlik AB, Turkey	Al Udeid, Qatar

This assessment shows several similar preferred options suggesting the current model is correctly assessing the potential airfields. The rank ordering for these bases differs, signifying the detail of the current model and the decision maker expertise has an affect on the list of preferred en route bases. There are also several potential airfields that differ. The top ten airfields from the current model are beneficial for bases other than the west coast US bases. If the origins in the eastern US are substantially used the bases displayed above are preferred choices.

Destination 3: Southeast Asia (Dili, Indonesia)

Table 4.11 below shows a comparison between the original model and the previous model for the top ten en route airfields for Dili, Indonesia.

Table 4.11. Comparison of Top Ten En Route Bases for Southeast Asia.

Current Model Results	Previous Model Results
Misawa AB, Japan	Kadena AB, Japan
Yokota AB, Japan	Clark AB, Philippines
Thumrait, Oman	Mactan International, Philippines
Seeb International, Oman	Andersen AFB, Guam
Iwakuni MCAS, Japan	U-Taphao, Thailand
Andersen AB, Guam	Darwin, Australia
Darwin, Australia	Changi, Singapore
Clark AB, Philippines	Paya Lebar, Singapore
Paya Lebar, Singapore	Iwakuni MCAS, Japan
Changi, Singapore	Yokota AB, Japan

This comparison illustrates more than half of the bases are common between the two models. This again demonstrates the soundness of the current model. The common results show bases that are currently in the ERS. This is promising because Southeast Asia is reachable through the current ERS requiring less money spent establishing a new en route base. However, these bases are located in a single country requiring dependency on relations with this country. Including a second en route base would allow for increased flexibility and security against possible political disparities.

Destination 4. Southern Asia (Gao, India)

Table 4.12 below shows a comparison between the original model and the previous model for the top ten en route airfields for Gao, India.

Table 4.12. Comparison of Top Ten En Route Bases for Southern Asia.

Current Model Results	Previous Model Results
Constanta, Romania	Seeb International, Oman
Sigonella AB, Italy	Bahrain International, Bahrain
Burgas, Bulgaria	Kuwait International, Kuwait
Incirlik AB, Turkey	Incirlik AB, Turkey
Thumrait, Oman	U-Taphao, Thailand
Seeb International, Oman	Thumrait, Oman
Iwakuni MCAS, Japan	Constanta, Romania
Kuwait International, Kuwait	Al Udeid, Qatar
Bahrain International, Bahrain	Ali Al Salem, Kuwait
Ali Al Salem, Kuwait	Burgas, Bulgaria

These results show the majority of the top ten for the models are common. The differing rank order indicates a difference in detail and emphasis of the model. The inclusion of eight common airfields suggests these airfields are indeed the most optimal en route airfields. However, none of the airfields listed above are part of the current ERS. This reveals a possible need to incorporate one of these airfields into the ERS.

Southern Asia is an area surrounded by countries with turbulent political and civil environments. This is an area that has a likelihood of needing military or other assistance from the US. Thus, access to this region could be required.

Destination 5. Northeastern Asia (Seoul AB, Republic of Korea)

Table 4.13 below shows a comparison between the original model and the previous model for the top ten en route airfields for Seoul, Republic of Korea.

Table 4.13. Comparison of Top Ten En Route Bases for Northeastern Asia.

Current Model Results	Previous Model Results
Elmendorf AFB, Alaska	Elmendorf AFB, Alaska
Misawa AB, Japan	Kadena AB, Japan
Yokota AB, Japan	Yokota AB, Japan
Iwakuni MCAS, Japan	Iwakuni MCAS, Japan
Andersen AB, Guam	Misawa AB, Japan
Darwin, Australia	Clark AB, Philippines
Kadena AB, Japan	Mactan International, Philippines
Clark AB, Philippines	Andersen AB, Guam
Paya Lebar, Singapore	U-Taphao, Thailand
Changi, Singapore	Changi, Singapore

The results comparison above show the eight of ten bases are the same between the two models. This suggests these are the optimal en route bases for operations to Seoul. Five of the bases shown are in the current ERS and are not all in a single country. These two properties are beneficial because money need not be spent on developing a new en route base and the dependence on relations with a single country can be eliminated.

Destination 6. Southern Africa (Waterkloof, South Africa)

Table 4.14 below shows a comparison between the original model and the previous model for the top ten en route airfields for Waterkloof, South Africa.

Table 4.14. Comparison of Top Ten En Route Bases for South Africa.

Current Model Results	Previous Model Results
Kotoka, Ghana	Seeb, Oman
Libreville, Gabon	Moi, Kenya
Seeb, Oman	Bahrain International, Bahrain
Entebbe, Uganda	Ascension AUX AF, Ascension
Kuwait International, Kuwait	Lusaka International, Zambia
Ali Al Salem, Kuwait	Kuwait International, Kuwait
Bahrain International, Bahrain	Al Udeid, Kuwait
Al Udeid, Kuwait	Libreville, Gabon
Ascension AUX AF, Ascension	Ali Al Salem, Kuwait
Moi, Kenya	Entebbe, Uganda

The above comparison shows nine of ten potential en route bases matching between the two models. This is an indication these nine airfield are candidates for additions to the ERS. However, none of the above bases are currently in the ERS. Thus, en route airfields do not exist to provide a way to support operations to South Africa through the ERS. An addition to the ERS to access South Africa would allow for future operations to the region and enhance the global reach of the ERS.

Destination 7. Western Africa (Monrovia, Liberia)

Table 4.15 below shows a comparison between the original model and the previous model for the top ten en route airfields for Monrovia, Liberia.

Table 4.15. Comparison of Top Ten En Route Bases for Western Africa.

Current Model Results	Previous Model Results
RAF Fairford, England	Lajes, Portugal
Roosevelt Roads, Puerto Rico	Rota NAS, Spain
Rota NAS, Spain	Moron AB, Spain
Ramstein AB, Germany	Sigonella, Italy
Moron AB, Spain	RAF Fairford, England
Lajes, Portugal	Spangdahlem AB, Germany
Dakar, Senegal	Ramstein AB, Germany
Mildenhall AB, United Kingdom	Mildenhall AB, United Kingdom
Spangdahlem AB, Germany	Dakar, Senegal
Constanta, Romania	Incirlik AB, Turkey

The comparison above shows eight of ten potential airfields match between the current and previous models. It can be reasoned these eight bases are candidates for the optimal en route airfield to fly to Western Africa. Also, six of the ten airfields are part of the ERS. This is beneficial because no addition money needs to be spent on developing a new en route base. These are also spread through different countries reducing reliance on a single country.

Destination 8. Southern South America (Bahia Blanca, Argentina)

Table 4.16 below shows a comparison between the original model and the previous model for the top ten en route airfields for Bahia Blanca, Argentina.

Table 4.16. Comparison of Top Ten En Route Bases for Southern South America.

Current Model Results	Previous Model Results
Roosevelt Roads, Puerto Rico	Roosevelt Roads, Puerto Rico
Augusto Severo, Brazil	Ascension AUX AF, Ascension
Ascension AUX AF, Ascension	Augusto Severo, Brazil

The results for Southern South America show only three potential en route airfields because these are the only feasible solutions. The remaining en routes evaluated have a critical leg that is too long for direct flight without in-air refueling and so they are removed from the list of potential bases. None of the above bases are part of the current ERS. Also, South America is an area of political turmoil that has a potential for military or humanitarian operations in the future. This region may require the addition of an en route base for support of these missions since there is currently little or no support available.

The comparison of the current model and the previous model shows that there are many common top ranked airfields. Thus, the current model can be interpreted as a valid model while the differences between the models can be viewed as a result of the decision maker’s expertise and preferences.

Analysis

Three experiments were conducted to study the sensitivity of a decision maker’s preferences on the rank order of en route bases.

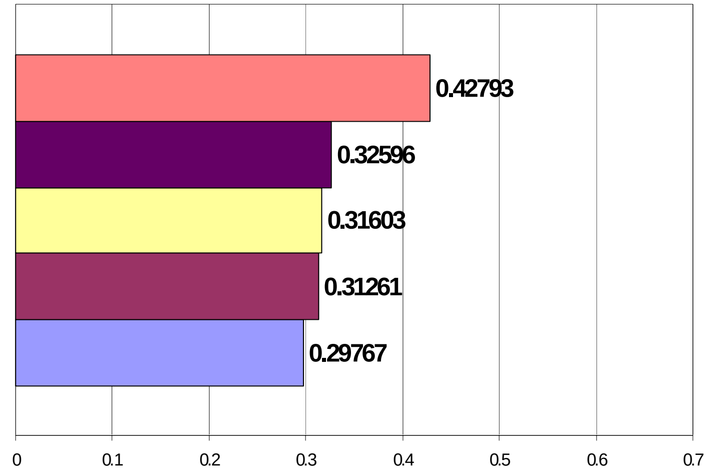
Experiment One evaluated the affect, on the overall rank ordering of bases, of changing the decision maker preference structure. Originally, the subject matter experts (SME) weighted Throughput as 25 percent and Sustainment 75 percent of the overall decision. Experiment One varied the weight on Throughput from 0.5 to 0.9. Sustainment was weighted to maintain a weight sum of one. The score for each en route was calculated as the mean of all origin-destination pairs. The boundary at which the rank ordering begins to change is when Throughput has a weight of 70 percent and Sustainment had a weight of 30 percent. For each destination, a comparison is made against the original preference structure to show the affects of different preference structures.

Destination 1: Southwest Asia (Baghdad International, Iraq)

Table 4.17 below shows a comparison of the results between the original model and Experiment One for Baghdad International, Iraq.

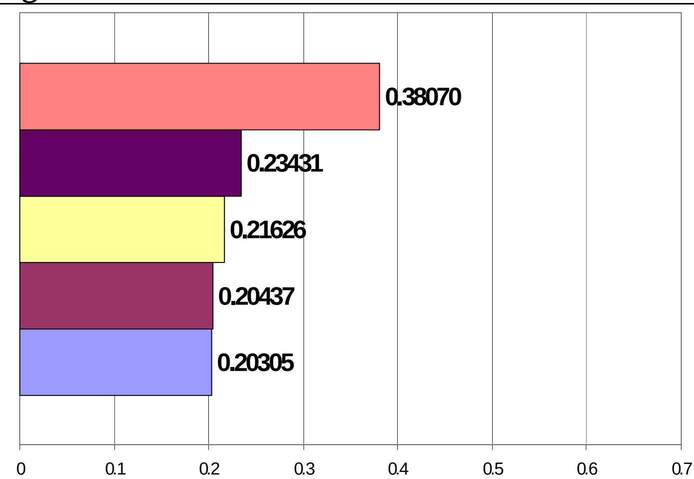
Table 4.17. Comparison of Original Model and Experiment 1 for Southwest Asia.

RAF Fairford, England
Ramstein AB, Germany
Rota NAS, Spain
Lajes, Portugal
Moron AB, Spain



Original Preference Structure

RAF Fairford, England
Ramstein AB, Germany
Rota NAS, Spain
Lajes, Portugal
Moron AB, Spain



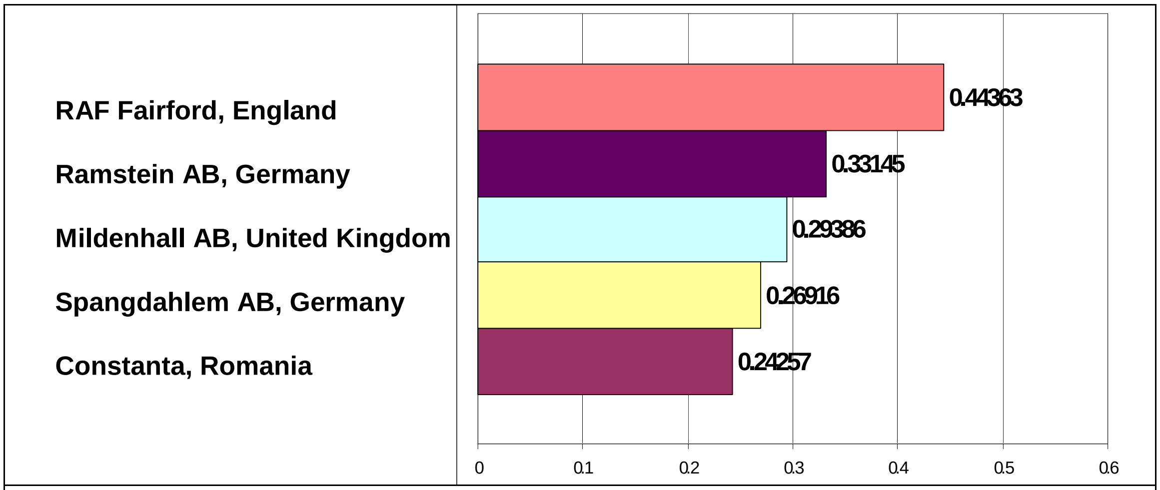
Adjusted Preference Structure

Table 4.17 illustrates the changes that adjusting the preference structure, weights of the measures, can have on the final decision. The top five bases do not change for Baghdad International, Iraq. This is expected because the ERS was built with a focus on Southwest Asia. Therefore, the top ranking bases should remain the same because these are well-developed airfields scoring well on all measures of the hierarchy.

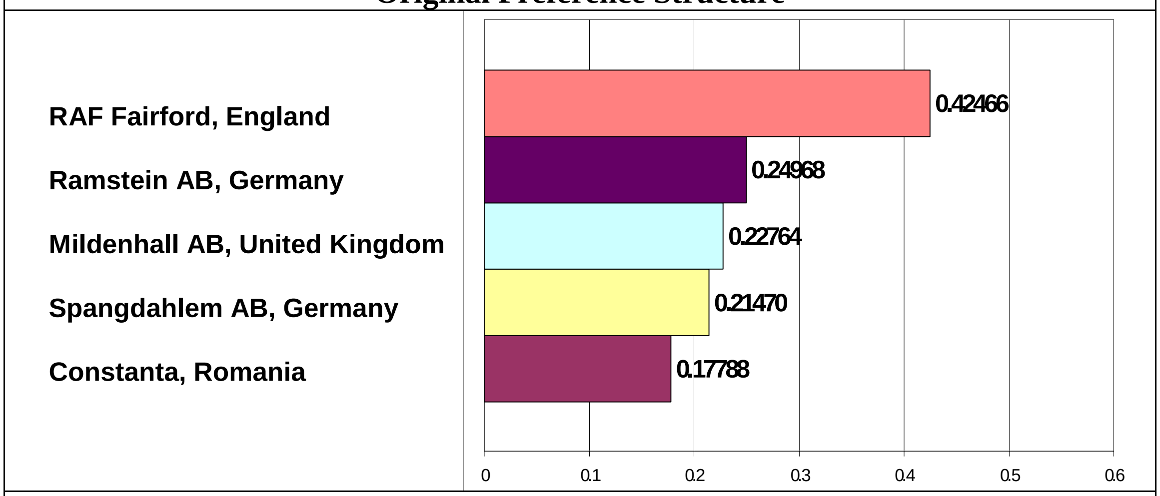
Destination 2: Central Asia (Lahore, Pakistan)

Table 4.18 shows the comparison of the original preference structure and Experiment One for Lahore, Pakistan. The top five bases for each model are displayed below.

Table 4.18. Comparison of Original Model and Experiment 1 for Central Asia.



Original Preference Structure



Adjusted Preference Structure

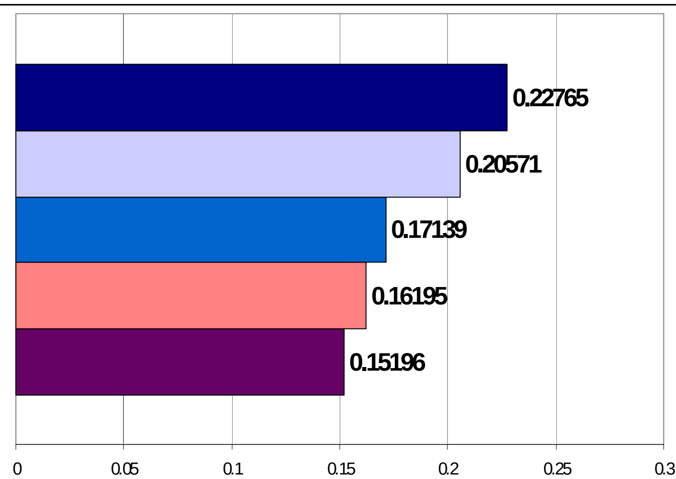
These results also show the top five en routes do not change for the destination Lahore, Pakistan. Central Asia is a region that is accessible from the current ERS and the lack of change shows that the current ERS is adequate for this region even with preference structure changes.

Destination 3: Southeast Asia (Dili, Indonesia)

Table 4.19 below shows a comparison of the results between the original preference structure and Experiment One for Dili, Indonesia.

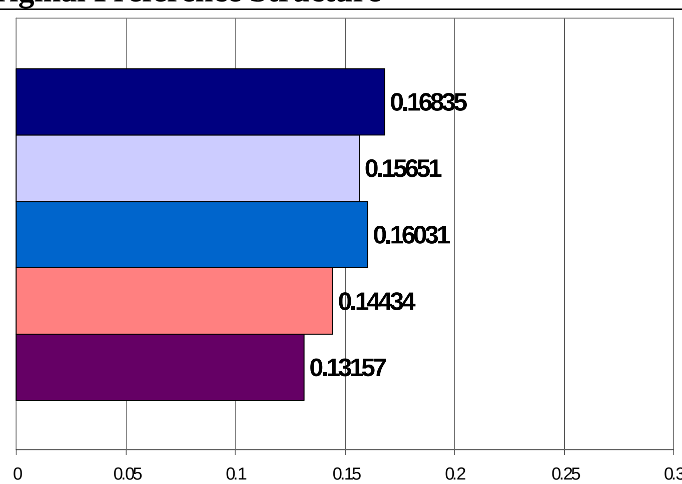
Table 4.19. Comparison of Original Model and Experiment 1 for Southeast Asia.

Misawa AB, Japan
Yokota AB, Japan
Thumrait, Oman
Seeb, Oman
Iwakuni MCAS, Japan



Original Preference Structure

Misawa AB, Japan
Yokota AB, Japan
Thumrait, Oman
Seeb, Oman
Iwakuni MCAS, Japan



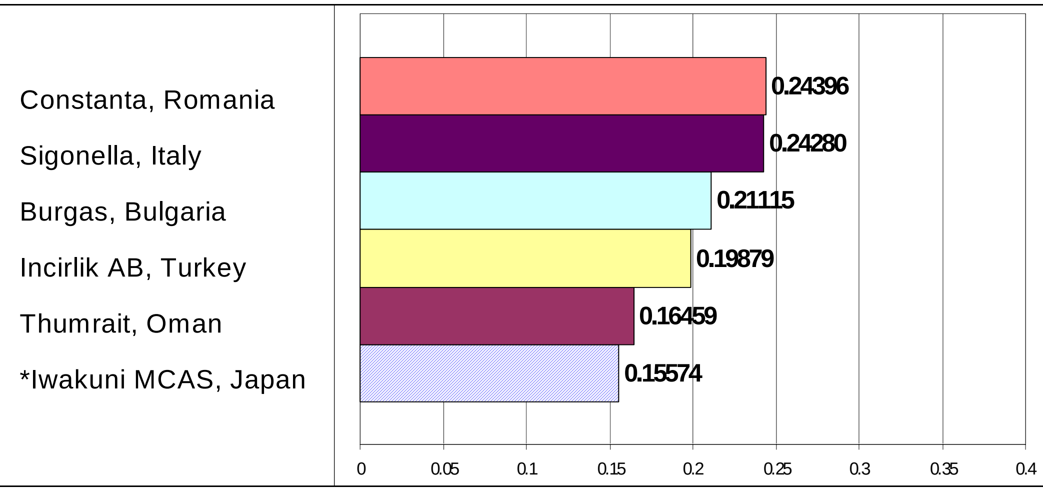
Adjusted Preference Structure

These results show that while the top five bases do not change, the rank ordering does change. This is an indication that the final decision could change when the decision maker's preference structure changes. For example; Thumrait, Oman rises from third to the second most preferred when weights are changed.

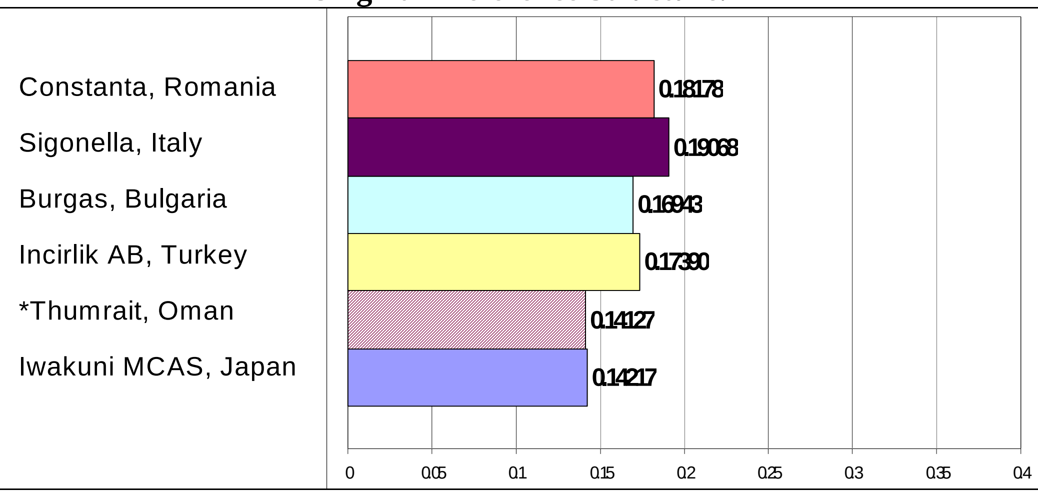
Destination 4. Southern Asia (Gao, India)

Table 4.20 below shows a comparison of the results between the original preference structure and Experiment One for Gao, India.

Table 4.20. Comparison of Original Model and Experiment 1 for Southern Asia.



Original Preference Structure.



Adjusted Preference Structure.

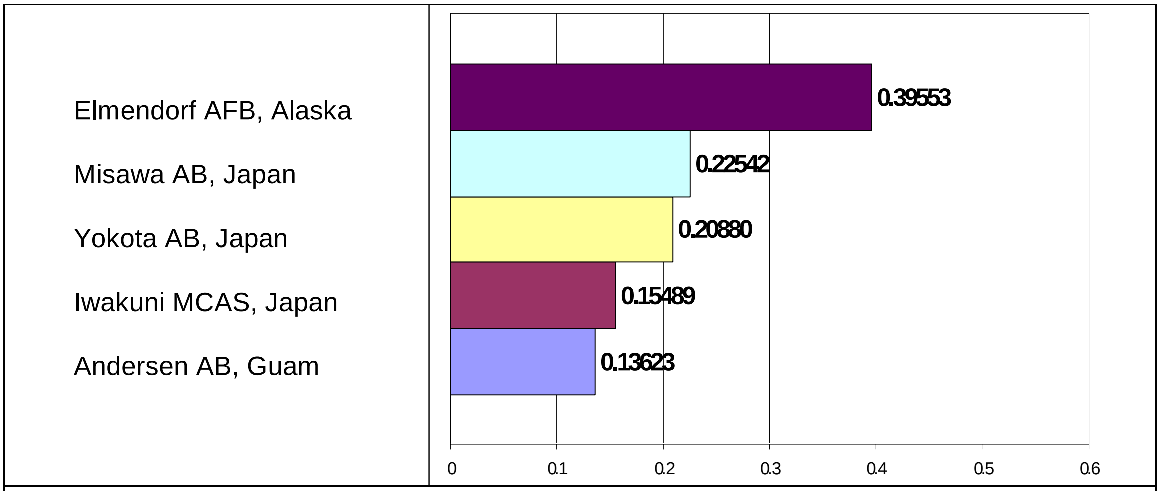
Note: * - the airfield is not ranked in the top five for the associated experiment.

The results of Gao, India show how a change in preference structure alters the rank ordering of the alternatives. In the original model, the top five includes Thumrait, Oman. However, for the adjusted preference structure, Thumrait drops out of the top five and Iwakuni MCAS, Japan becomes the fifth preferred en route airfield. This is an example of how changing the weights on the hierarchy can alter the model outcome. Two other changes also occurred in the rank ordering. Sigonella, Italy rises to the most preferred en route airfield and Constanta, Romania drops to second and Incirlik AB, Turkey rises to the third most preferred en route base while Burgas, Bulgaria drops to fourth. This is a good example that different preferences can affect many aspect of the decision.

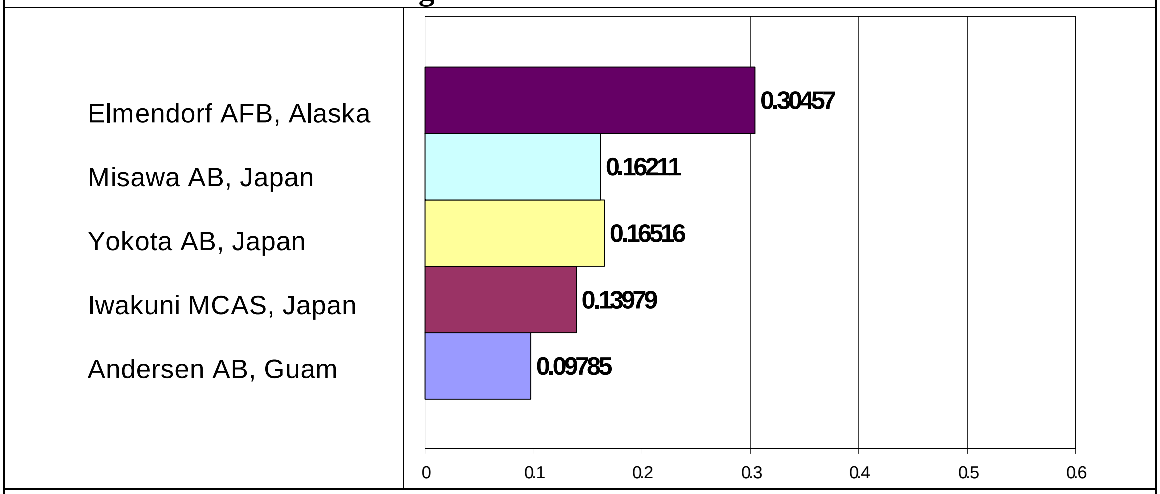
Destination 5. Northeastern Asia (Seoul AB, Republic of Korea)

Table 4.21 below shows a comparison of the results between the original preference structure and Experiment One for Seoul, Republic of Korea.

Table 4.21. Comparison of Original Model and Experiment 1 for Northeastern Asia.



Original Preference Structure.



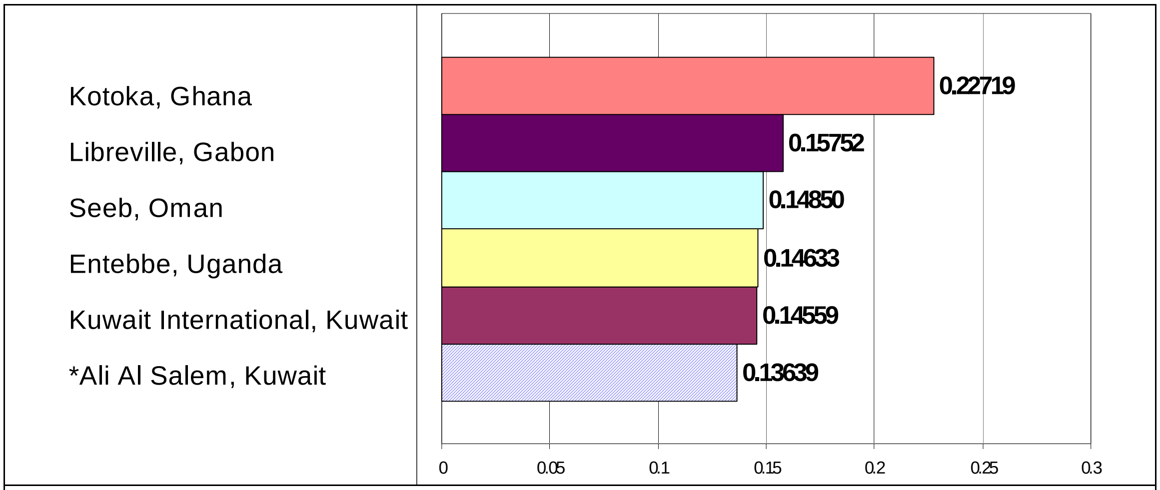
Adjusted Preference Structure.

The results for Seoul, Republic of Korea show only small changes due to alterations in preference structure. The top five remain the same for both preference structures. However, the rank changes slightly as Yokota AB, Japan moves from third to second preferred for the adjusted preference structure. This is only a slight change but shows that a different weighting construction can modify the model output.

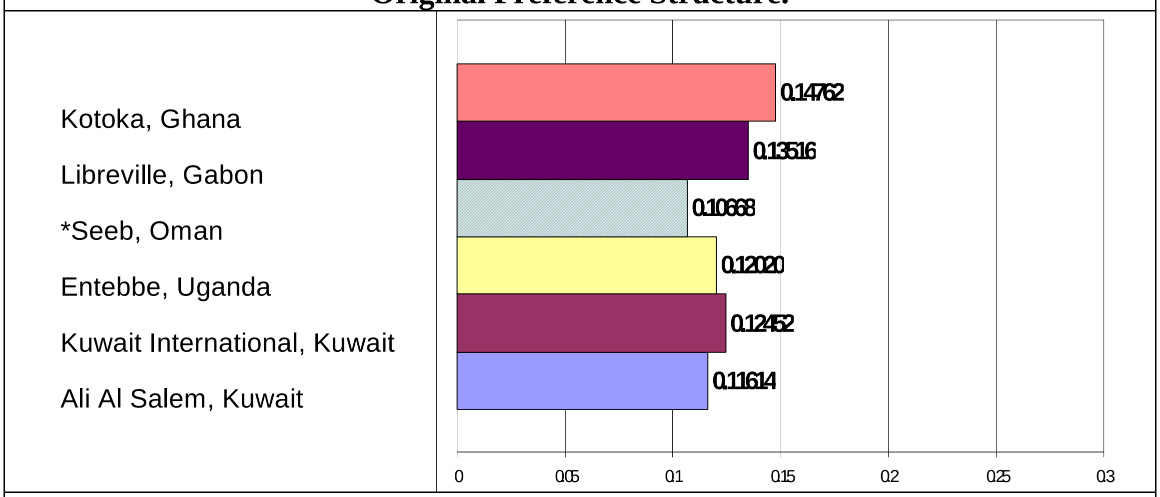
Destination 6. Southern Africa (Waterkloof, South Africa)

Table 4.22 below shows a comparison of the results between the original preference structure and Experiment One for Waterkloof, South Africa.

Table 4.22. Comparison of Original Model and Experiment 1 for Southern Africa.



Original Preference Structure.



Adjusted Preference Structure.

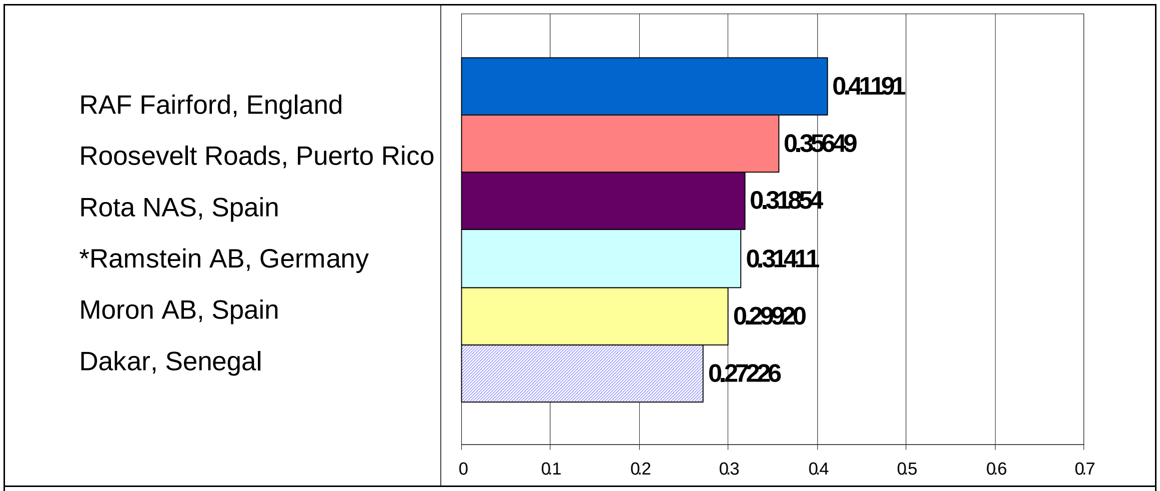
Note: * - the airfield is not ranked in the top five for the associated experiment.

The results for Waterkloof, South Africa show a more drastic change in the rank order of airfields. In this case, Ali Al Salem, Kuwait does not rank in the top five for the original preference structure but becomes the third most preferred en route base in Experiment One. Another change that also occurred is Kuwait International, Kuwait rises one rank and Entebbe, Uganda drops one rank thus bringing Kuwait International to the third preferred airfield. For this region, the decision maker could have a different list of preferred airfields depending on the hierarchy weighting. Thus, indicating the possible sweeping changes that can result from different preferences.

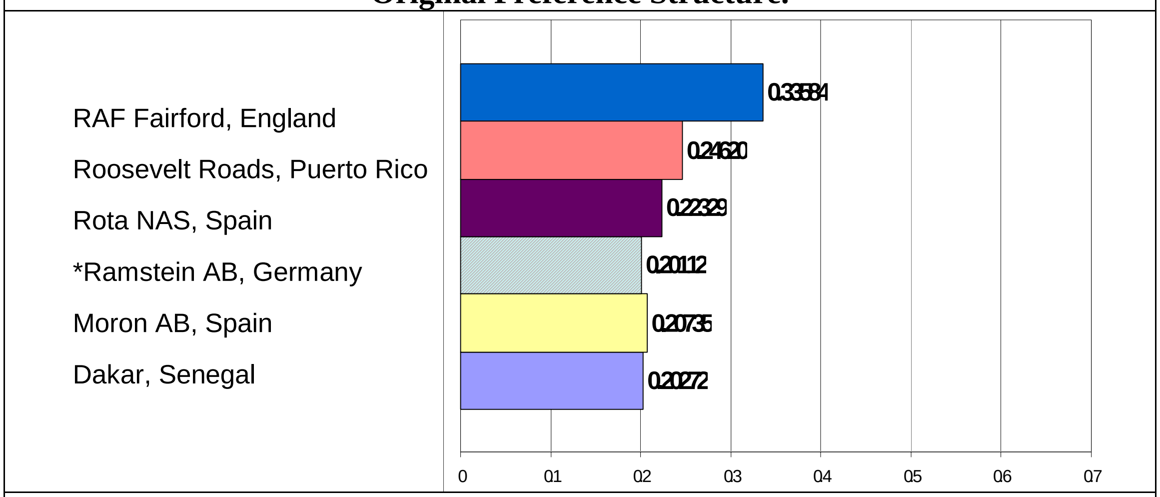
Destination 7. Western Africa (Monrovia, Liberia)

Table 4.23 below shows a comparison of the results between the original preference structure and Experiment One for Monrovia, Liberia.

Table 4.23. Comparison of Original Model and Experiment 1 for Western Africa.



Original Preference Structure.



Adjusted Preference Structure.

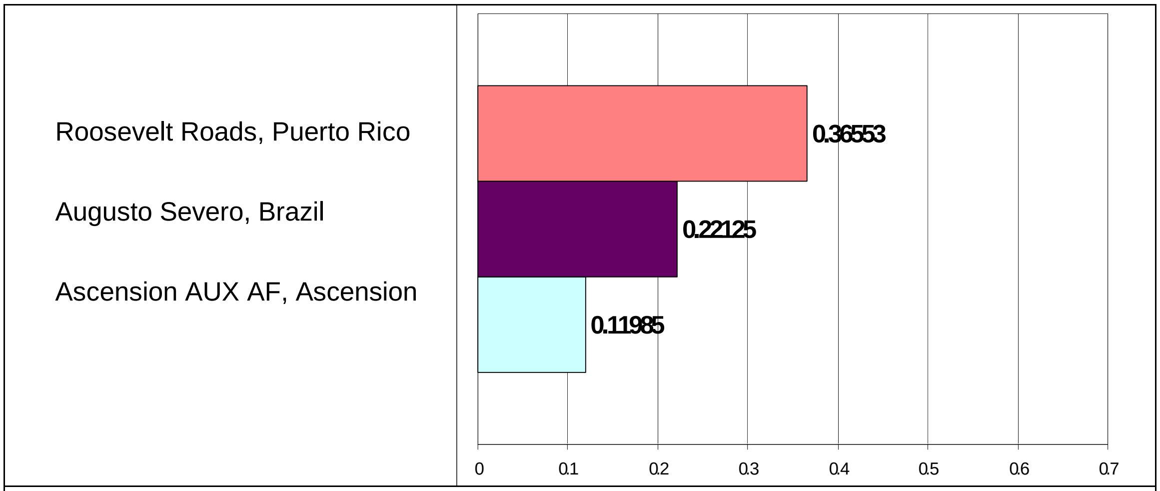
Note: * - the airfield is not ranked in the top five for the associated experiment.

This comparison is another example of how changing a preference structure can alter the model output. Originally, Ramstein AB, Germany is the third most preferred airfield. Once the hierarchy weighting is adjusted, Ramstein drops out of the top five and Dakar, Senegal becomes the fifth most preferred en route airfield. This is a major change since Ramstein is part of the ERS and Dakar, Senegal is not. This change shows how preferences can alter the outcome.

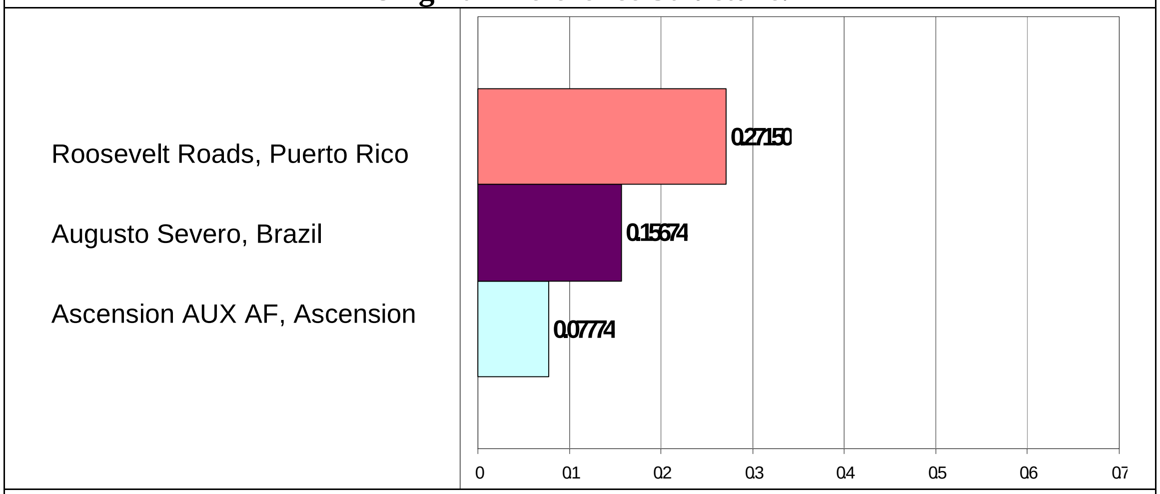
Destination 8. Southern South America (Bahia Blanca, Argentina)

Table 4.24 below shows a comparison of the results between the original preference structure and Experiment One for Bahia Blanca, Argentina.

Table 4.24. Comparison of Original Model and Experiment 1 for South America.



Original Preference Structure.



Adjusted Preference Structure.

The results for Argentina are, as expected, the same for both preferences structures. There are only three results of Argentina because these are the only feasible en route bases being evaluated in this research. The change is preference structure does not change the rank ordering of these bases indicating Roosevelt Roads, Puerto Rico is likely the optimal en route airfield for Argentina.

In summary, three regions are affected by the change in preference structures. The top five preferred en route bases for Southern Africa, Western Africa, and Southern

Asia experienced changes. Waterkloof, South Africa experiences the most drastic change when the third most preferred base; Seeb, Oman; drops from the top five and Ali Al Salem becomes the fifth preferred base. The top five for Monrovia, Liberia changes when the fourth preferred base; Ramstein AB, Germany; drops from the top five and Dakar, Senegal becomes the fifth preferred en route base. Finally; the top five for Gao, India is modified when the fifth preferred base; Thumrait, Oman; is replaced by Iwakuni MCAS, Japan.

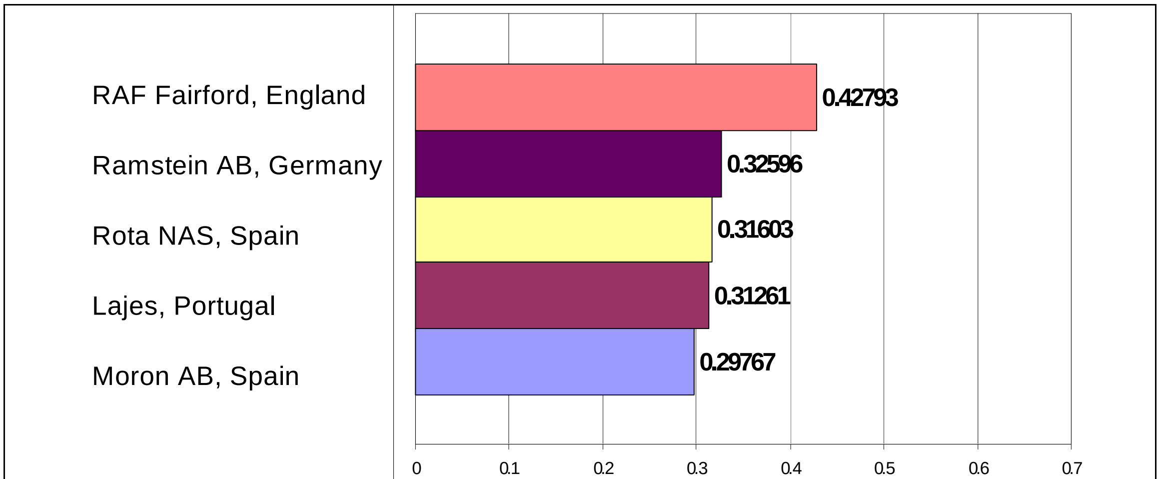
These results show that changes in preference structures can change the model outcome. Thus, different decision makers with distinct preferences can have dissimilar results and make differing final decisions. However, since only a few destinations had major changes, this suggests that the model is robust enough to avoid extreme output differences.

Experiment Two considered the amount of traffic originating from the CONUS bases; McChord AFB, Travis AFB, Charleston AFB, and Dover AFB; versus the remaining eight origin bases. The CONUS bases are, generally, used as origin bases more often than those outside the US. The question is then asked, does the increased airlift traffic through the CONUS origins and an increased focus on these bases influence the rank ordering of the potential airfields. For this experiment, the original preference structure is maintained and the CONUS bases are given an increased weight in the averaging of scores. The magnitude of the weight was varied between two and six times that of the remaining eight bases. The value of three was chosen because of the changes in the rank order that began to occur at this level. For each destination, a comparison is made between the original model and Experiment Two.

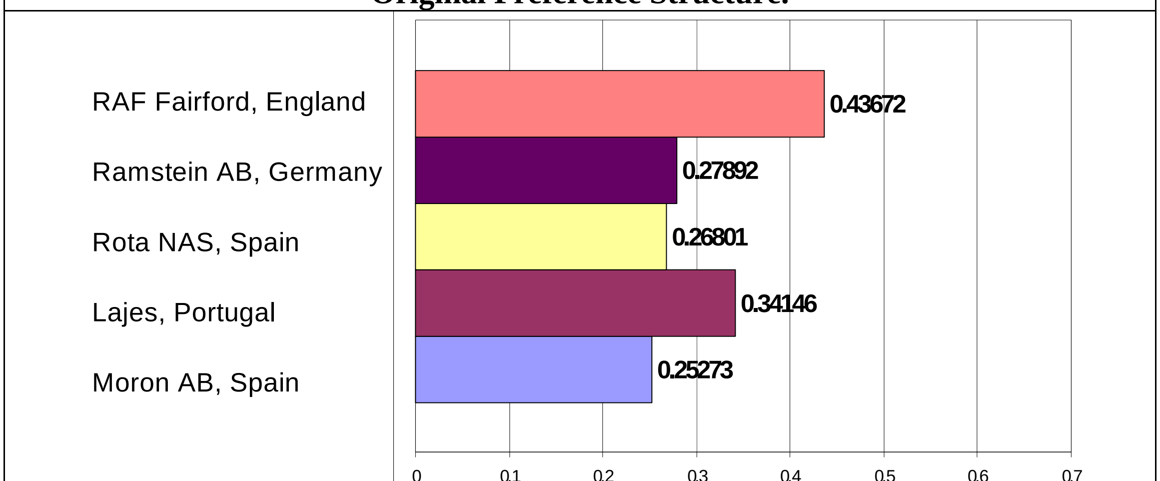
Destination 1: Southwest Asia (Baghdad International, Iraq)

Table 4.25 below shows a comparison between the original model and Experiment Two for Baghdad International, Iraq.

Table 4.25. Comparison of Original Model and Experiment 2 for Southwest Asia.



Original Preference Structure.



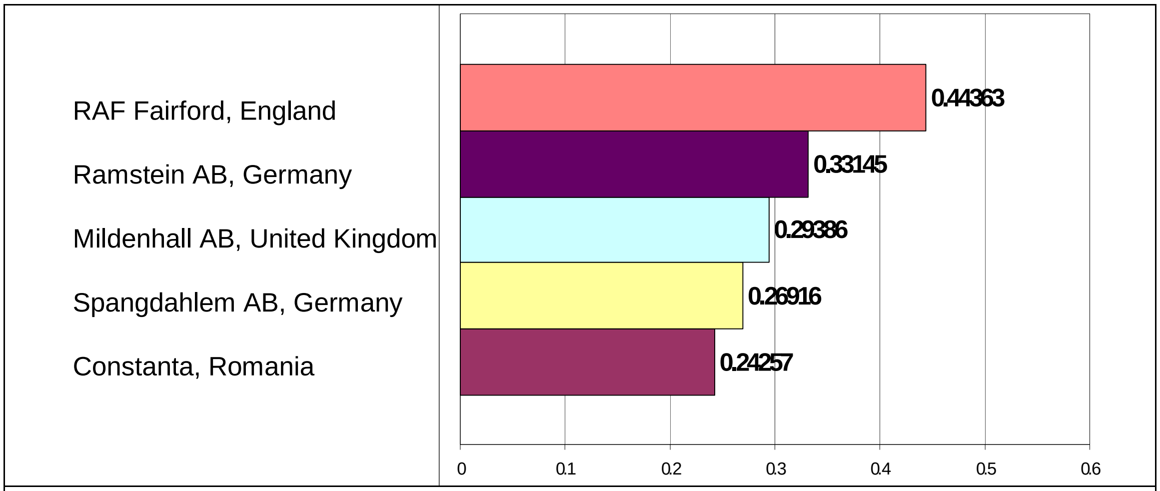
Weighted CONUS Origins.

The results above show that the top five en route airfields for Baghdad International, Iraq do not change when the CONUS origins are weighted more heavily. Thus, although most flights originate from the CONUS bases; RAF Fairford, England is the most preferred en route base for Southwest Asia. Since the ERS was built to access this region, this result is expected.

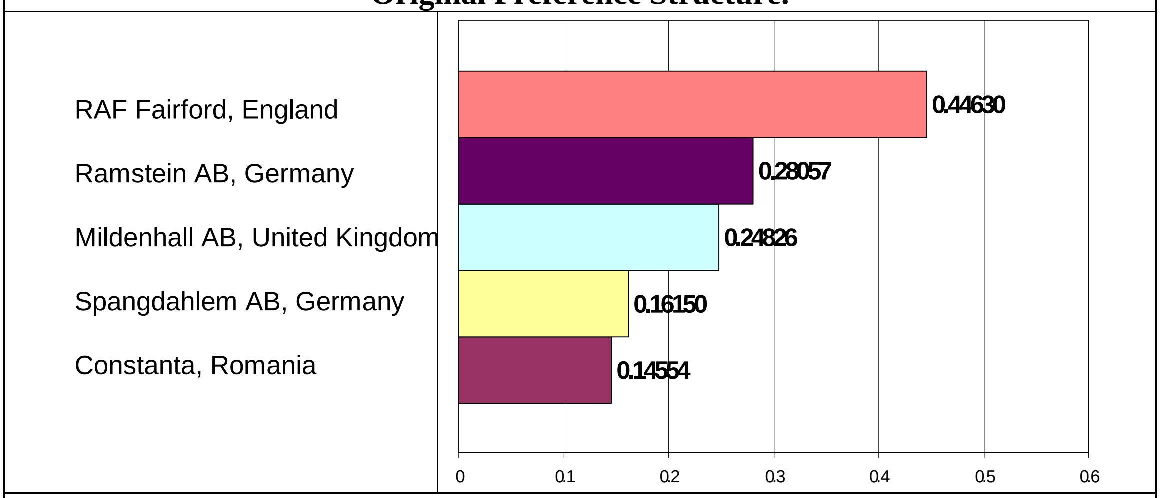
Destination 2: Central Asia (Lahore, Pakistan)

Table 4.26 shows the comparison of the original preference structure and Experiment Two for Lahore, Pakistan. The top five bases for each model are displayed below.

Table 4.26. Comparison of Original Model and Experiment 2 for Central Asia.



Original Preference Structure.



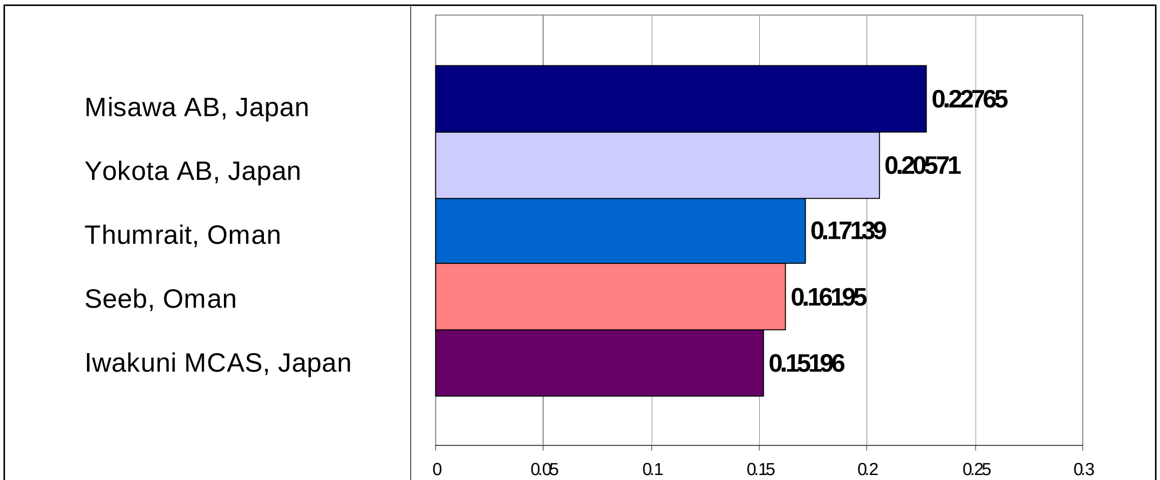
Weighted CONUS Origins.

The top five en route bases for Lahore, Pakistan do not change when increased weight is placed on the CONUS origins. RAF Fairford, England continues as the most preferred en route airfield for Lahore, Pakistan.

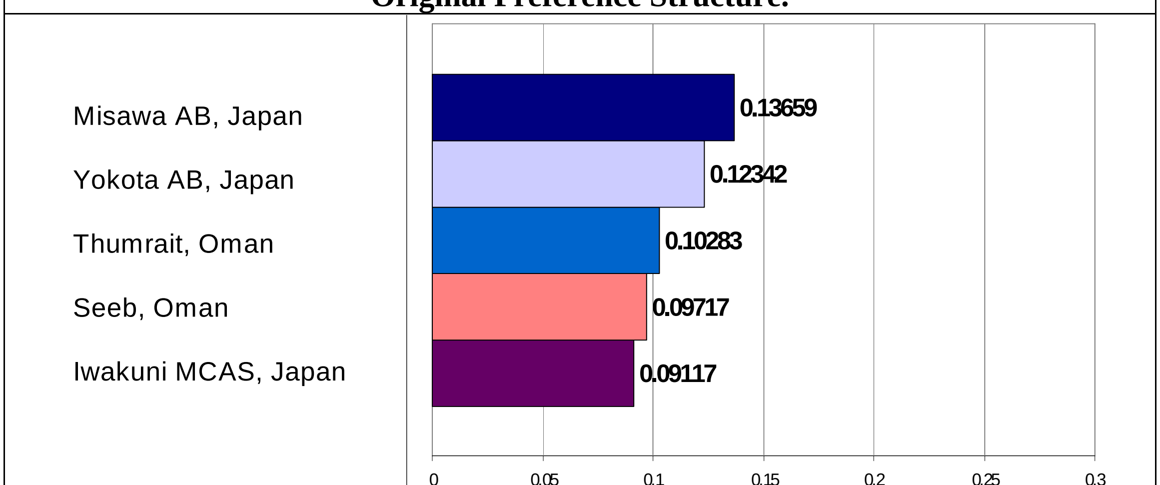
Destination 3: Southeast Asia (Dili, Indonesia)

Table 4.27 below shows a comparison of the results between the original preference structure and Experiment Two for Dili, Indonesia.

Table 4.27. Comparison of Original Model and Experiment 2 for Southeast Asia.



Original Preference Structure.



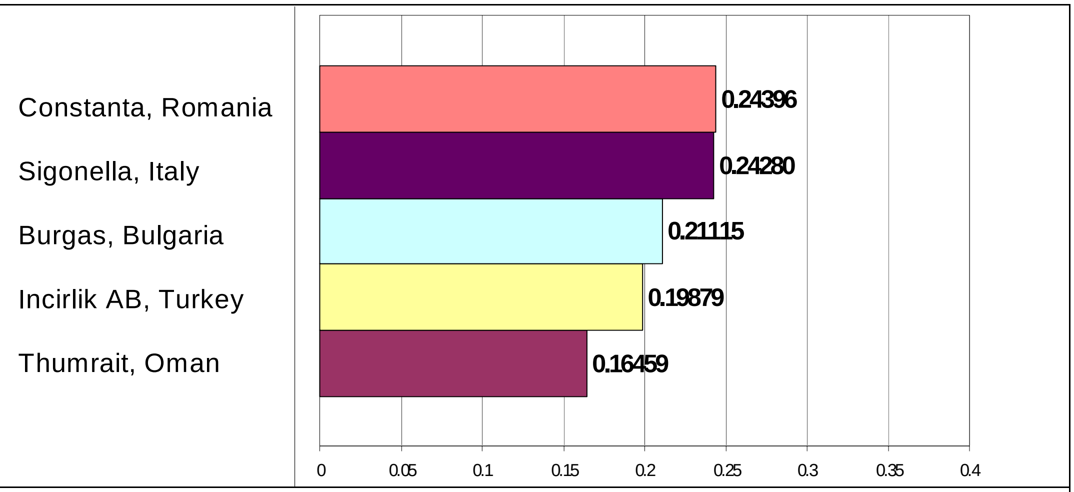
Weighted CONUS Origins.

The top five bases for Southeast Asia do not change as the emphasis on the CONUS origin changes. Misawa AB, Japan continues to be the most preferred en route airfield for Dili, Indonesia.

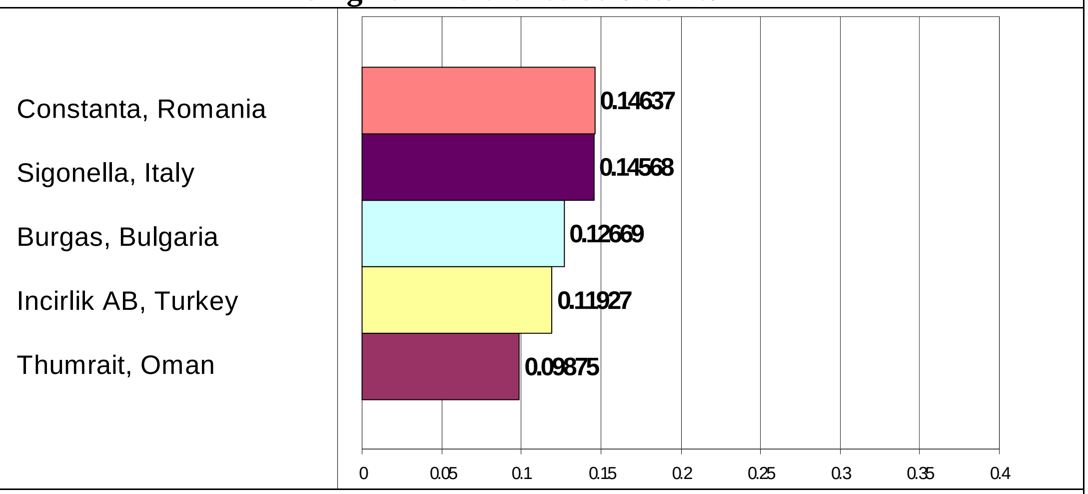
Destination 4. Southern Asia (Gao, India)

Table 4.28 below shows a comparison of the results between the original preference structure and Experiment Two for Gao, India.

Table 4.28. Comparison of Original Model and Experiment 2 for Southern Asia.



Original Preference Structure.



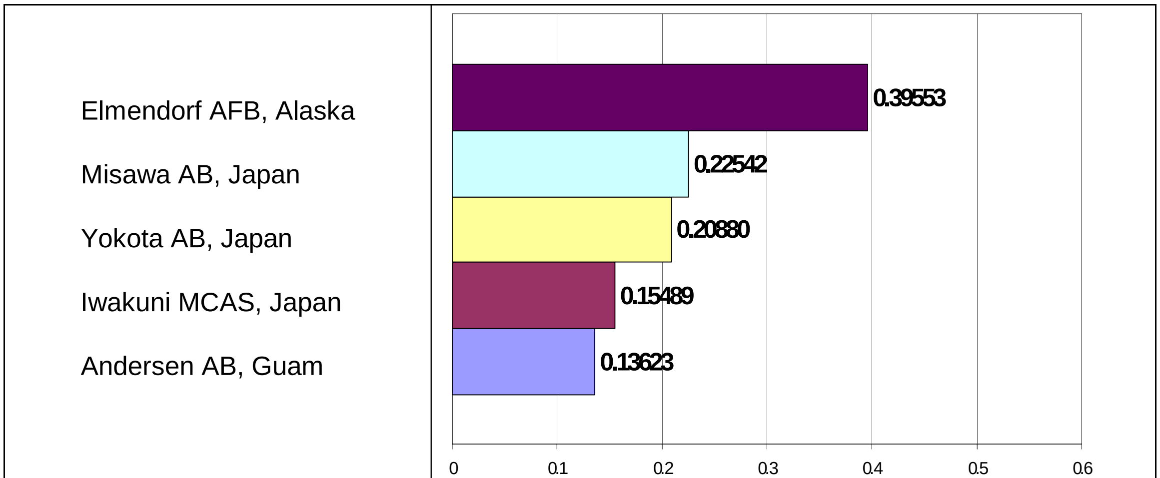
Weighted CONUS Origins.

The top five preferred en route bases for Southern Asia do not change when increased emphasis is placed on the CONUS origins. Constanta, Romania continues to be the most preferred potential en route airfield for Gao, India.

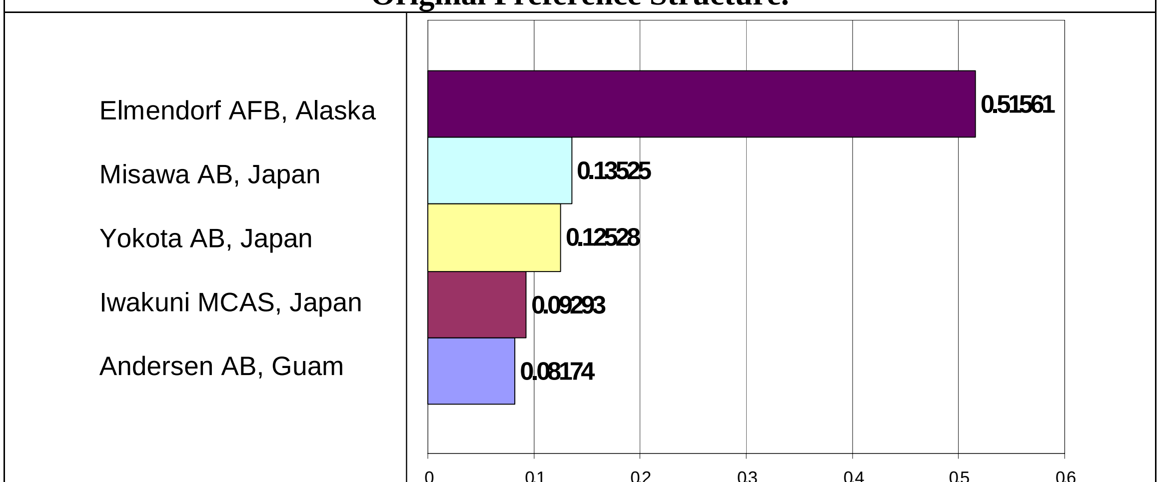
Destination 5. Northeastern Asia (Seoul AB, Republic of Korea)

Table 4.29 below shows a comparison of the results between the original preference structure and Experiment Two for Seoul, Republic of Korea.

Table 4.29. Comparison of Original Model and Experiment 2 for Northeastern Asia.



Original Preference Structure.



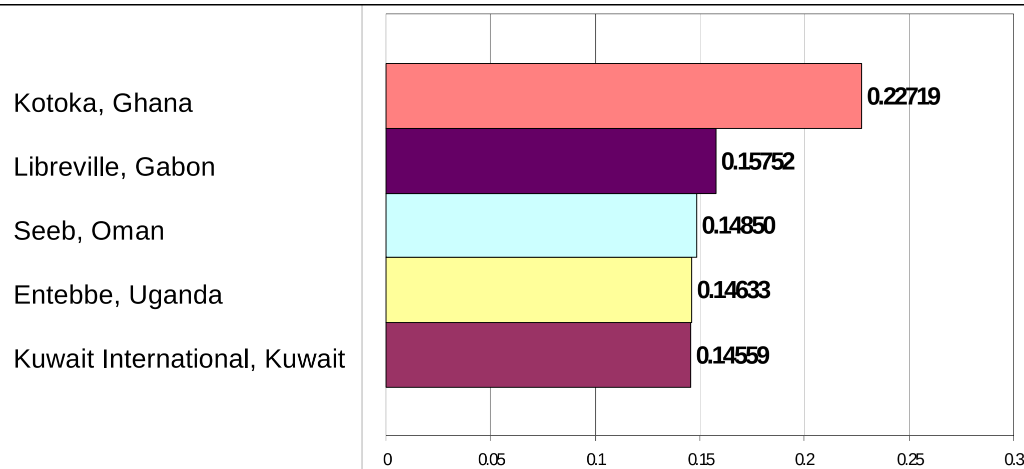
Weighted CONUS Origins.

The top five preferred en route bases for Northeastern Asia do not change when increased emphasis is placed on the CONUS origins. Elmendorf AFB, Alaska continues to be the most preferred potential en route airfield for Seoul, Republic of Korea. Thus, this region is not heavily influenced by the importance of the CONUS origins.

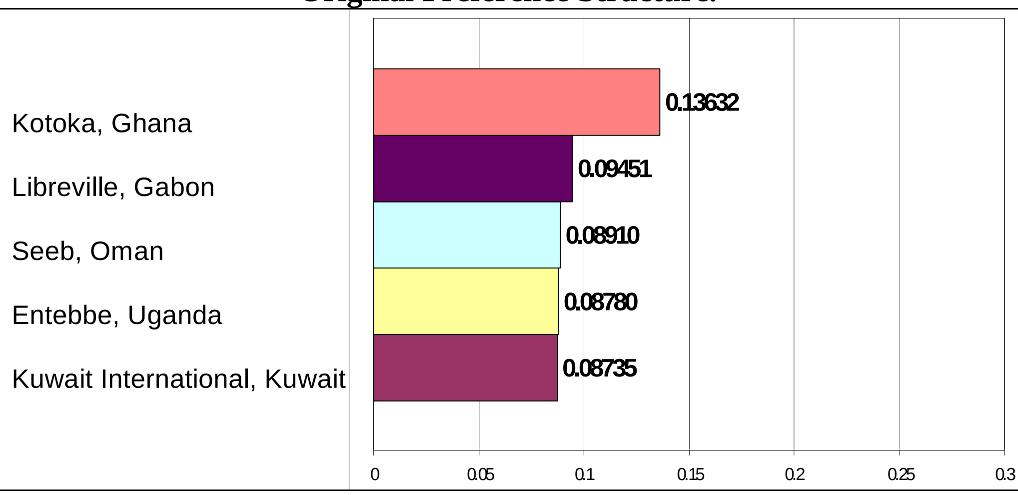
Destination 6. Southern Africa (Waterkloof, South Africa)

Table 4.30 below shows a comparison of the results between the original preference structure and Experiment Two for Waterkloof, South Africa.

Table 4.30. Comparison of Original Model and Experiment 2 for Southern Africa.



Original Preference Structure.



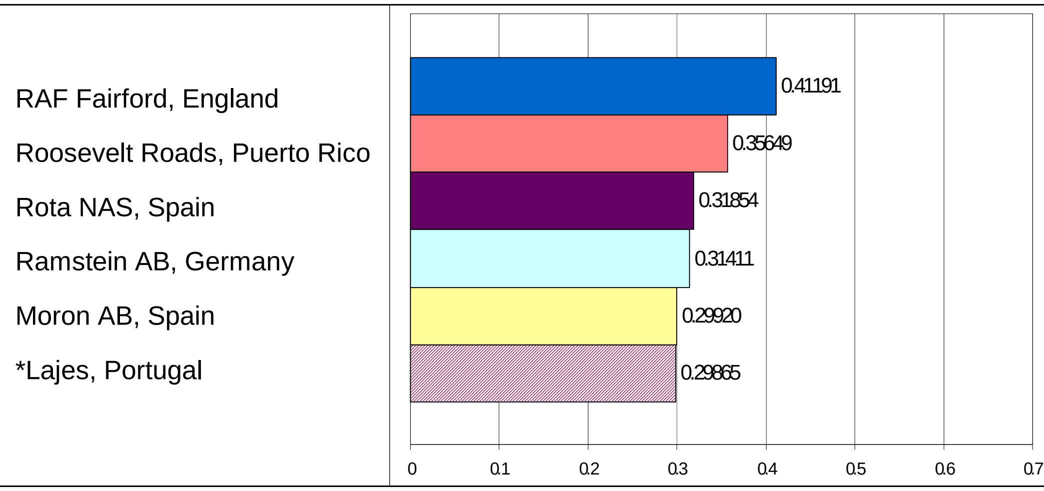
Weighted CONUS Origins.

This comparison shows, again, the top five preferred en route bases for Southern Africa do not change as increased emphasis is placed on the CONUS origins. Kotoka, Ghana remains the most preferred airfield for Waterkloof, South Africa.

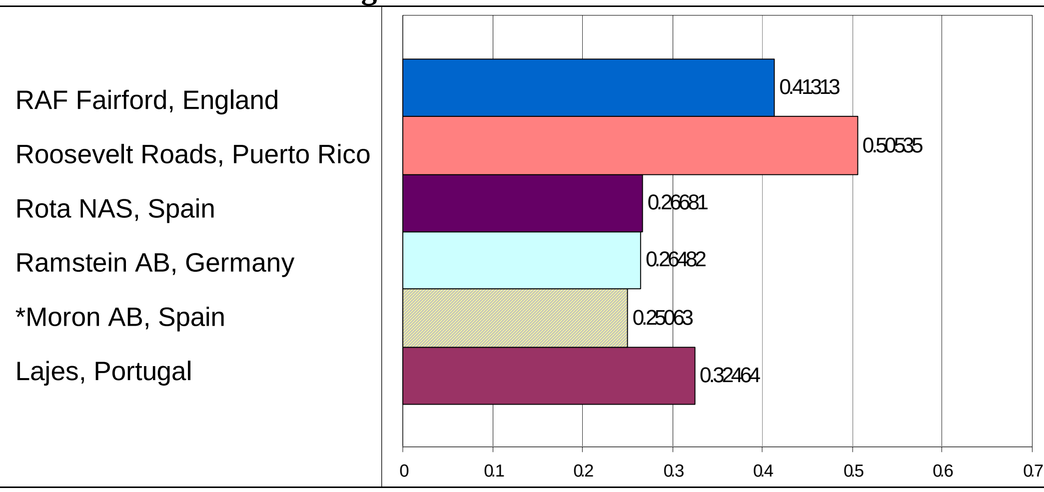
Destination 7. Western Africa (Monrovia, Liberia)

Table 4.31 below shows a comparison of the results between the original preference structure and Experiment Two for Monrovia, Liberia.

Table 4.31. Comparison of Original Model and Experiment 2 for Western Africa.



Original Preference Structure.



Weighted CONUS Origins.

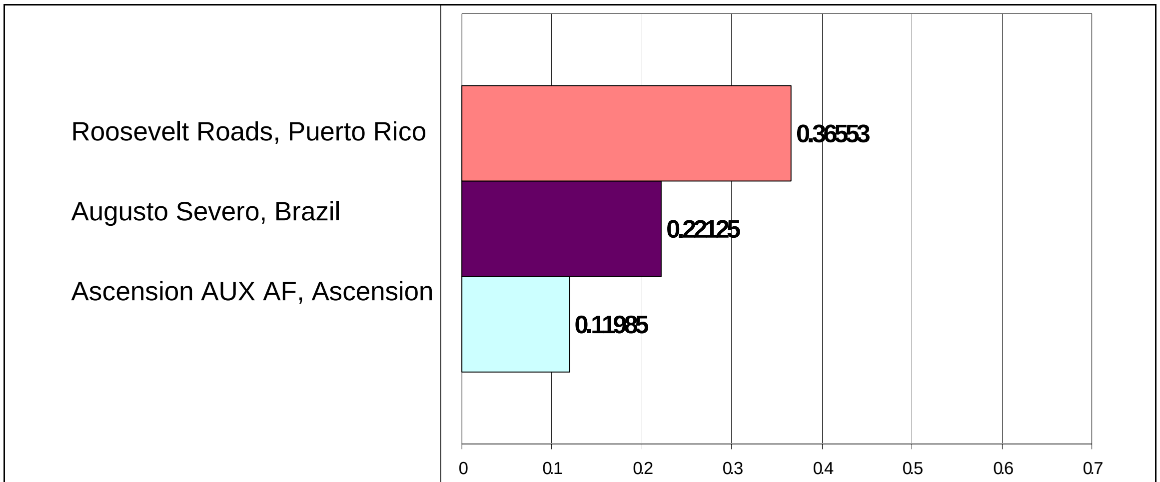
Note: * - the airfield is not ranked in the top five for the associated experiment.

This is the only comparison that shows a change in the top five preferred bases. In this comparison; Lajes, Portugal becomes the third preferred en route base while Moron AB, Spain drops from the top five for Monrovia, Liberia. This suggests that the en route chosen for Western Africa is subject to the change in emphasis on the CONUS origins. Thus, Lajes could be a beneficial replacement for Moron as a top five preferred en route airfield for Western Africa. Also, Roosevelt Roads, Puerto Rico becomes the most preferred en route base replacing RAF Fairford, England.

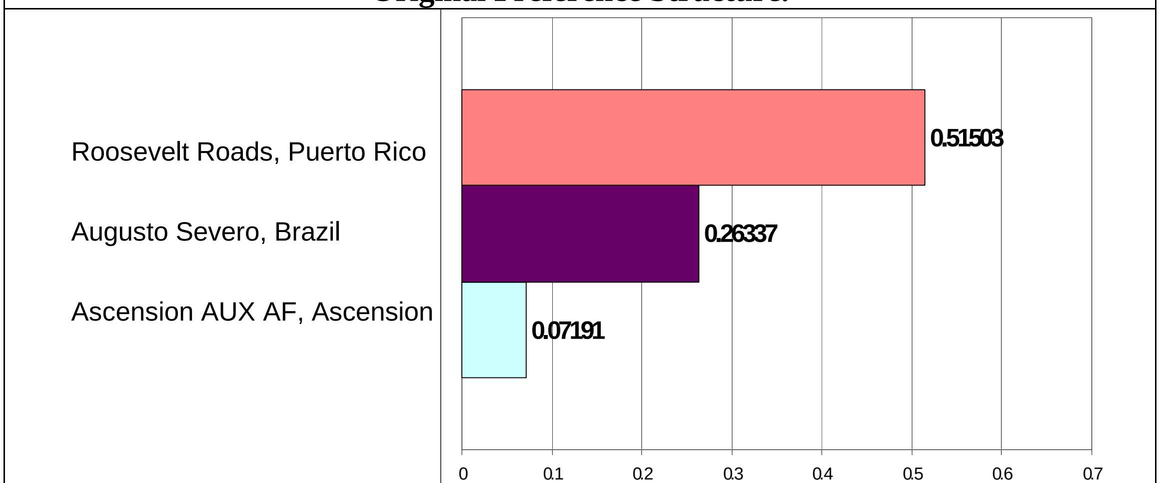
Destination 8. Southern South America (Bahia Blanca, Argentina)

Table 4.32 below shows a comparison of the results between the original preference structure and Experiment Two for Bahia Blanca, Argentina.

Table 4.32. Comparison of Original Model and Experiment 2 for South America.



Original Preference Structure.



Weighted CONUS Origins.

As expected, there is no change in the rank ordering of the en route bases for Southern South America. The rank is not affected by the change in emphasis on the CONUS origins. Roosevelt Roads, Puerto Rico continues to be the most preferred en route base for Bahia Blanca, Argentina.

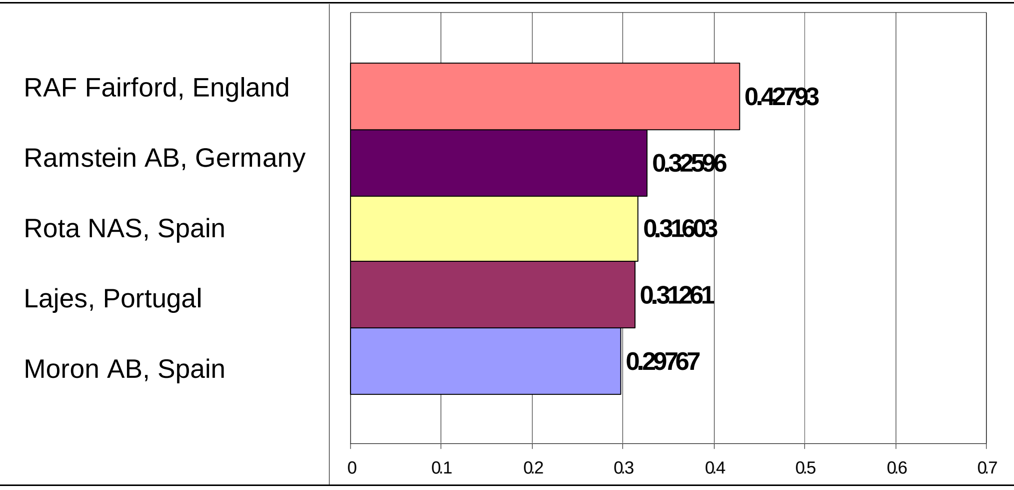
In summary, only one destination experiences a change in the top five preferred en route bases when increased emphasis is placed on the CONUS origins. The top five bases for Baghdad International, Iraq remain the same but the rank order changes. Lajes, Portugal moves from fourth preferred to second most preferred when the CONUS origins are weighted more than the remaining eight origins. The top five airfields also change for Monrovia, Liberia when Roosevelt Roads, Puerto Rico rises to the most preferred airfield and Lajes, Portugal becomes the third preferred en route base. These minimal alterations in rank ordering for the destinations show that the increased emphasis on the CONUS origins, at the level of three times the remaining eight origins, does not results in severe changes of the top five en route bases.

Experiment Three considers the affect of changing the weights on Throughput and Sustainment while also placing more emphasis on the CONUS origins. For this experiment, Throughput has a weight of 70 percent, Sustainment has a weight of 30 percent, and the CONUS origins; McChord AFB, Travis AFB, Charleston AFB, and Dover AFB; are weighted three times the remaining origins bases in the mean score calculation. The results of Experiment Three are compared with the original model for each destination.

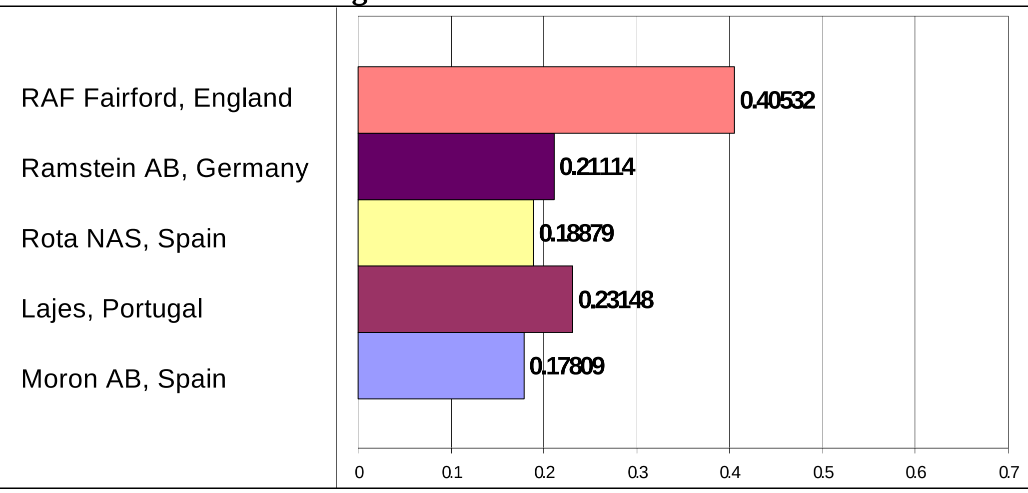
Destination 1: Southwest Asia (Baghdad International, Iraq)

Table 4.33 below shows a comparison between the original model and Experiment Three for Baghdad International, Iraq.

Table 4.33. Comparison of Original Model and Experiment 3 for Southwest Asia.



Original Preference Structure.



Adjusted Preference Structure and Weighted CONUS Origins.

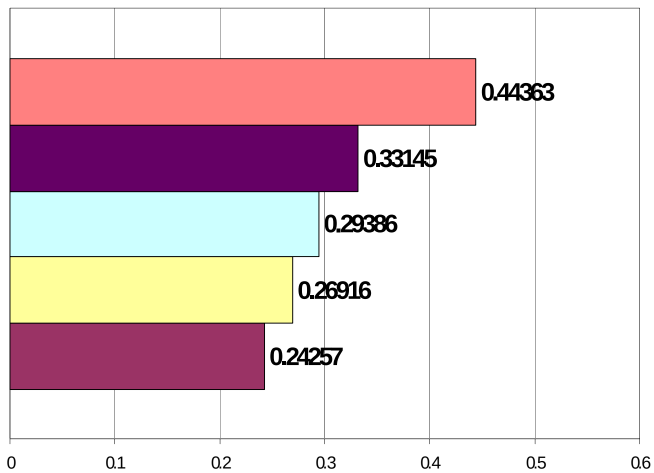
Lajes, Portugal rises to second most preferred en route base when the preference structure is altered and the CONUS origins are weighted. A similar result occurred in Experiment Two when only the CONUS origins are weighted. The preferred bases remain the same with only the reordering of the alternatives within the top five.

Destination 2: Central Asia (Lahore, Pakistan)

Table 4.34 shows the comparison of the original preference structure and Experiment Three for Lahore, Pakistan. The top five bases for each model are displayed below.

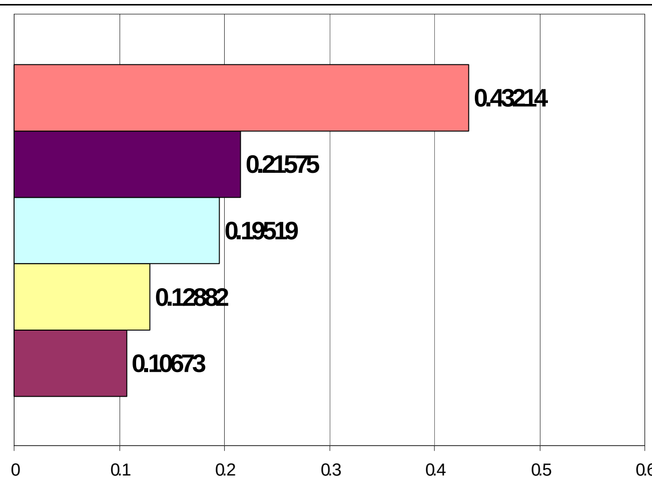
Table 4.34. Comparison of Original Model and Experiment 3 for Central Asia.

RAF Fairford, England
Ramstein AB, Germany
Mildenhall AB, United Kingdom
Spangdahlem AB, Germany
Constanta, Romania



Original Preference Structure.

RAF Fairford, England
Ramstein AB, Germany
Mildenhall AB, United Kingdom
Spangdahlem AB, Germany
Constanta, Romania



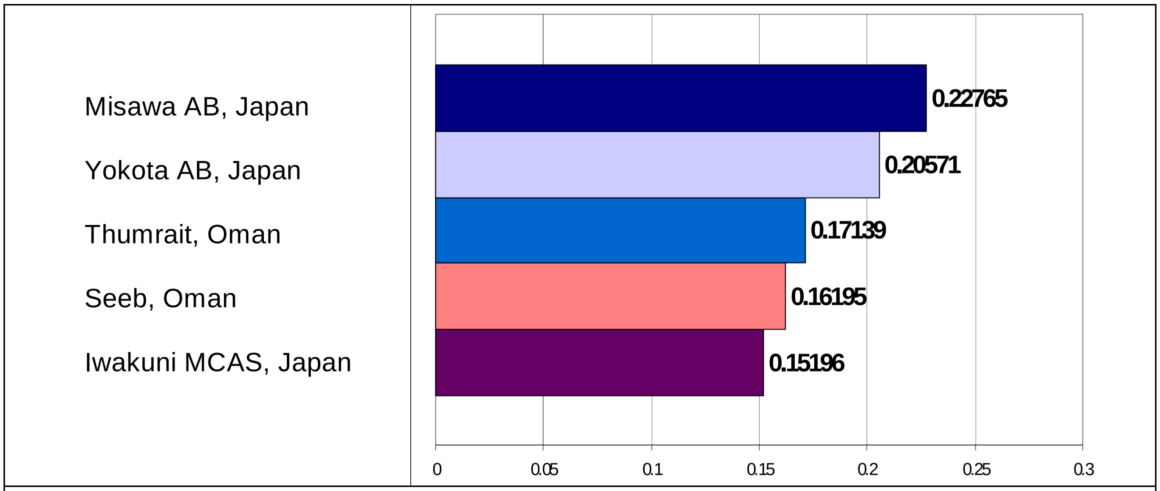
Adjusted Preference Structure and Weighted CONUS Origins.

As in Experiments One and Two, the top five bases are the same and maintain the same rank ordering for both the original preference structure and Experiment 3.

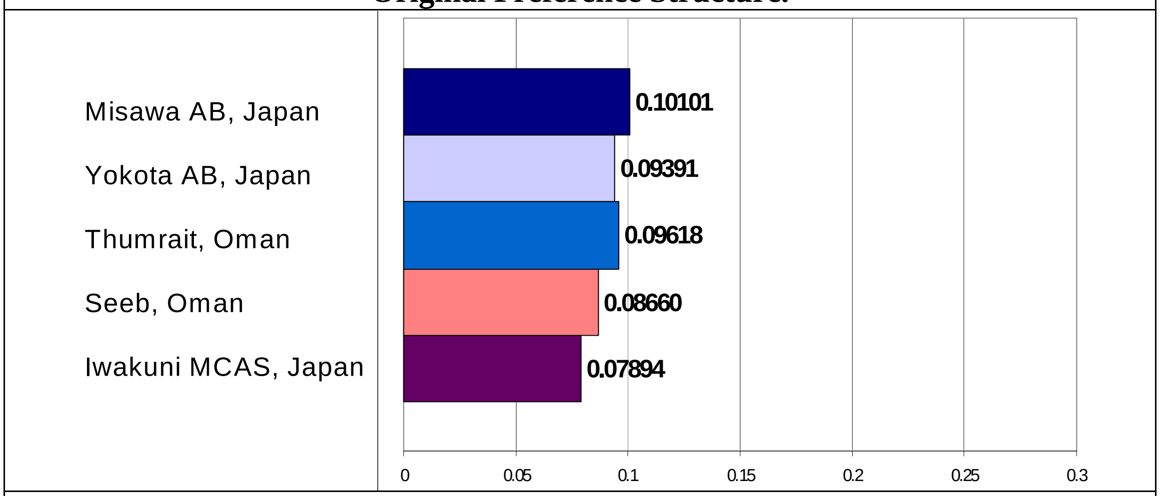
Destination 3: Southeast Asia (Dili, Indonesia)

Table 4.35 below shows a comparison of the results between the original preference structure and Experiment Three for Dili, Indonesia.

Table 4.35. Comparison of Original Model and Experiment 3 for Southeast Asia.



Original Preference Structure.



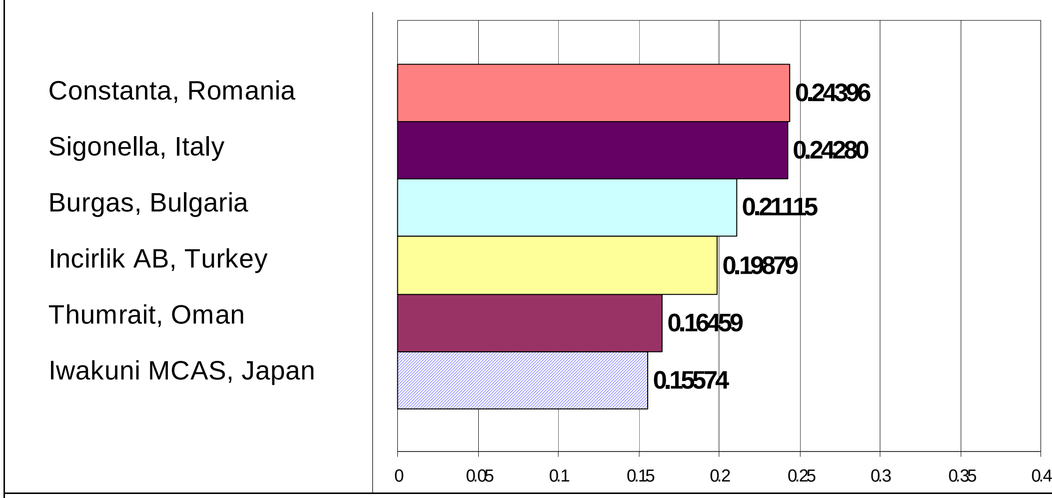
Adjusted Preference Structure and Weighted CONUS Origins.

The top five bases do not change but the rank ordering does change. Thumrait, Oman rises from third preferred in the original model to second most preferred in Experiment Three. This is similar to the change in Experiment Two and thus is an expected result.

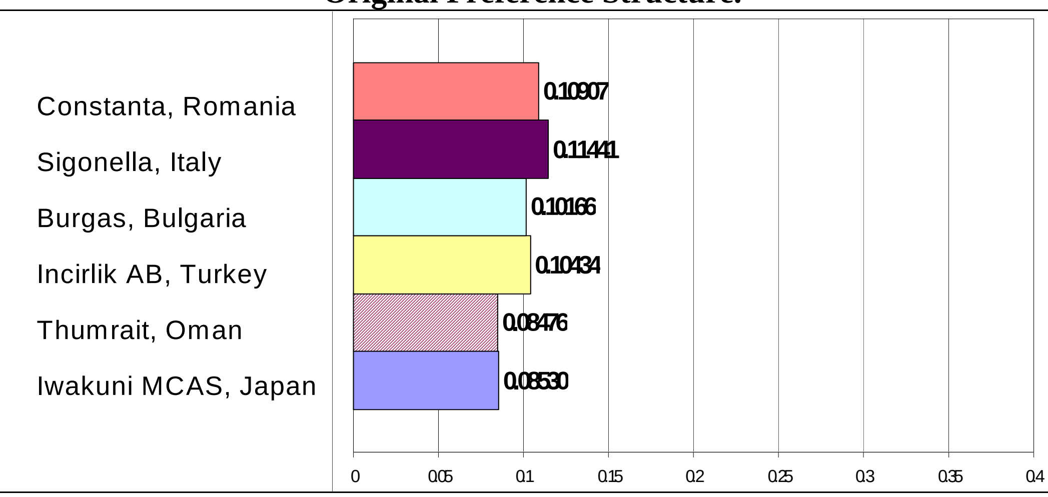
Destination 4. Southern Asia (Gao, India)

Table 4.36 below shows a comparison of the results between the original preference structure and Experiment Three for Gao, India.

Table 4.36. Comparison of Original Model and Experiment 3 for Southern Asia.



Original Preference Structure.



Adjusted Preference Structure and Weighted CONUS Origins.

Note: * - the airfield is not ranked in the top five for the associated experiment.

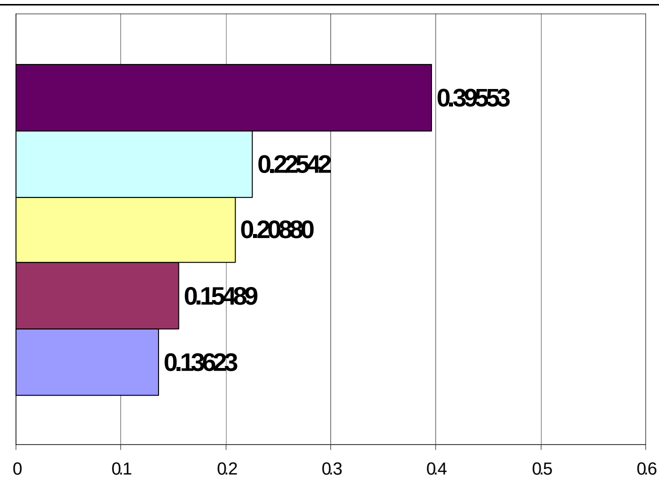
The results for Gao, India show consequences similar to those in Experiment One. Several changes in the rank ordering take place; including Sigonella, Italy rising to the most preferred en route airfield and Constanta, Romania dropping to second; Incirlik AB, Turkey rising to the third most preferred en route base while Burgas, Bulgaria drops to fourth; and finally Iwakuni MCAS, Japan becomes the fifth preferred base while Thumrait, Oman is eliminated from the top five. This is a clear indication of the affect of preference changes on the overall model output and possibly on the decision.

Destination 5. Northeastern Asia (Seoul AB, Republic of Korea)

Table 4.37 below shows a comparison of the results between the original preference structure and Experiment Three for Seoul, Republic of Korea.

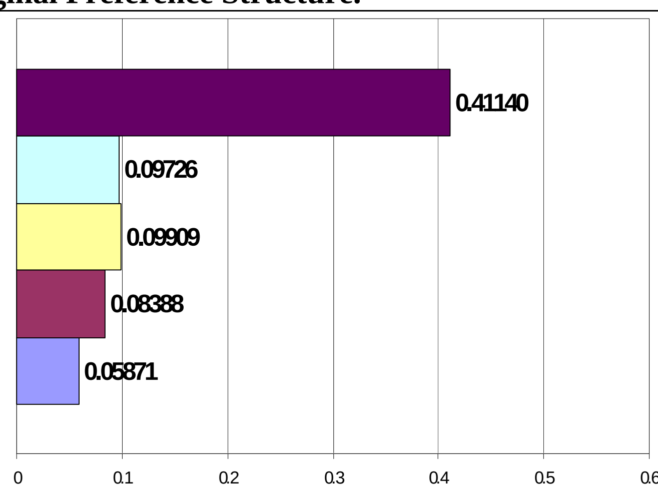
Table 4.37. Comparison of Original Model and Experiment 3 for Northeastern Asia.

Elmendorf AFB, Alaska
Misawa AB, Japan
Yokota AB, Japan
Iwakuni MCAS, Japan
Andersen AB, Guam



Original Preference Structure.

Elmendorf AFB, Alaska
Misawa AB, Japan
Yokota AB, Japan
Iwakuni MCAS, Japan
Andersen AB, Guam



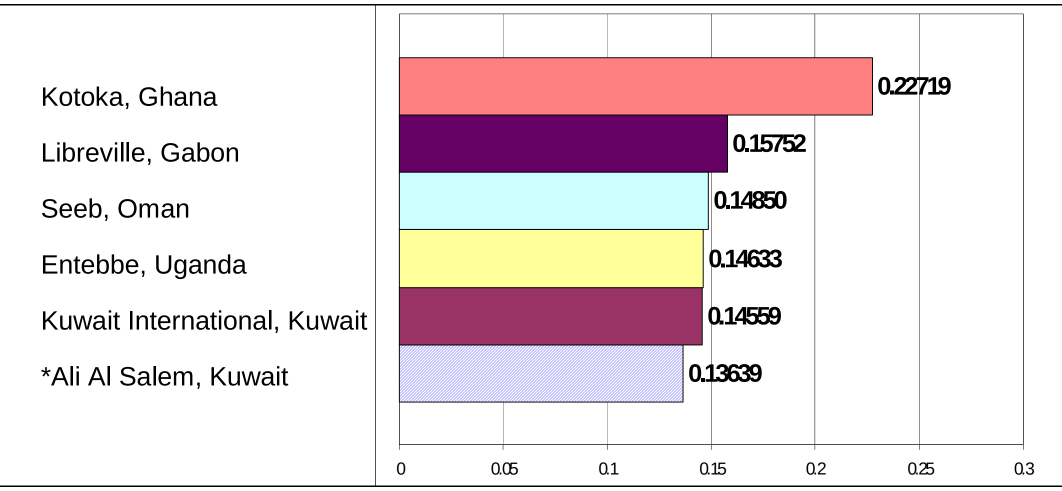
Adjusted Preference Structure and Weighted CONUS Origins.

A single change occurs in the rank order of the en route bases for Seoul, Republic of Korea. Yokota AB, Japan becomes the second most preferred en route airfield while Misawa AB, Japan drops from most to third preferred base. This is a slight change but it illustrates how preferences can change outcomes.

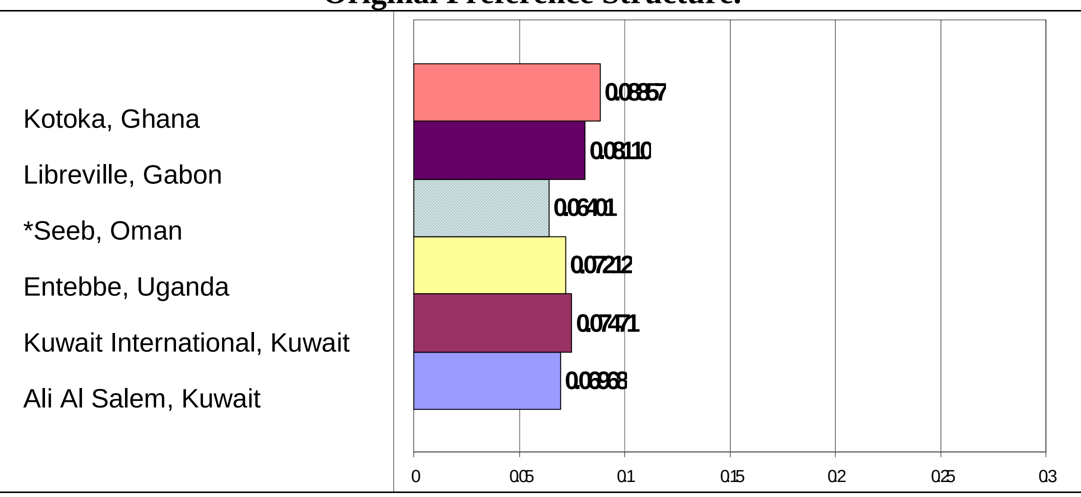
Destination 6. Southern Africa (Waterkloof, South Africa)

Table 4.38 below shows a comparison of the results between the original preference structure and Experiment Three for Waterkloof, South Africa.

Table 4.38. Comparison of Original Model and Experiment 3 for Southern Africa.



Original Preference Structure.



Adjusted Preference Structure and Weighted CONUS Origins.

Note: * - the airfield is not ranked in the top five for the associated experiment.

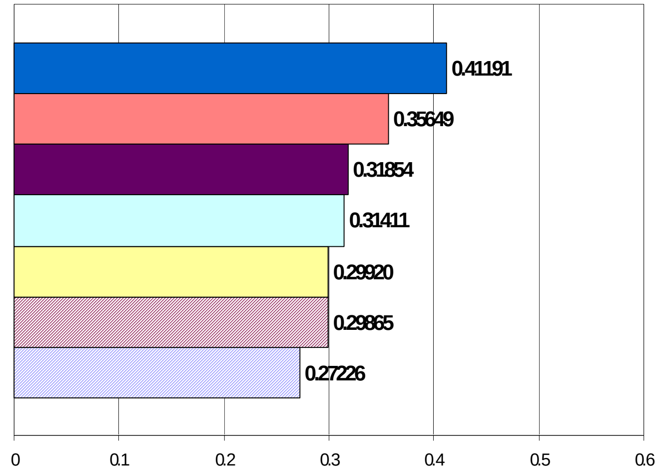
The above results show several changes in the order of the alternatives and what alternatives are included in the top five. The most dramatic change is the third preferred base; Seeb, Oman; is eliminated from the top five and Ali Al Salem, Kuwait becomes the fifth in the top five. The other, more minor changes are Kuwait International, Kuwait overtaking Entebbe, Uganda as the third most preferred base while Entebbe drops from third to fourth preferred en route airfield. This is a good example of how changes in hierarchy weights and focuses on certain aspects of a problem can cause changes in the results and possibly in the final decision.

Destination 7. Western Africa (Monrovia, Liberia)

Table 4.39 below shows a comparison of the results between the original preference structure and Experiment Three for Monrovia, Liberia.

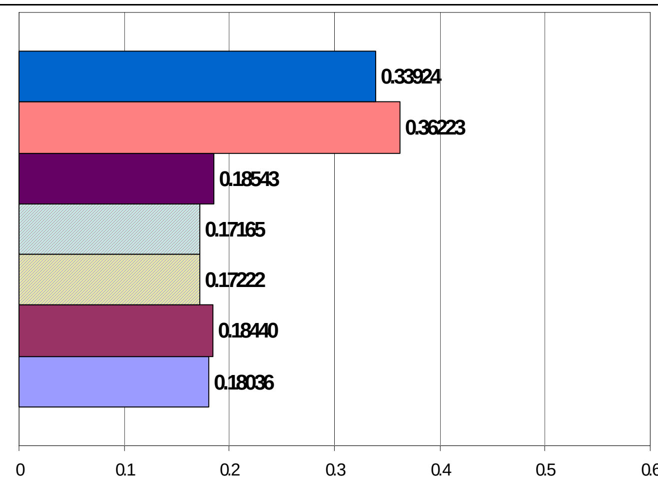
Table 4.39. Comparison of Original Model and Experiment 3 for Western Africa.

RAF Fairford, England
Roosevelt Roads, Puerto Rico
Rota NAS, Spain
Ramstein AB, Germany
Moron AB, Spain
*Lajes, Portugal
*Dakar, Senegal



Original Preference Structure.

RAF Fairford, England
Roosevelt Roads, Puerto Rico
Rota NAS, Spain
*Ramstein AB, Germany
*Moron AB, Spain
Lajes, Portugal
Dakar, Senegal



Adjusted Preference Structure and Weighted CONUS Origins.

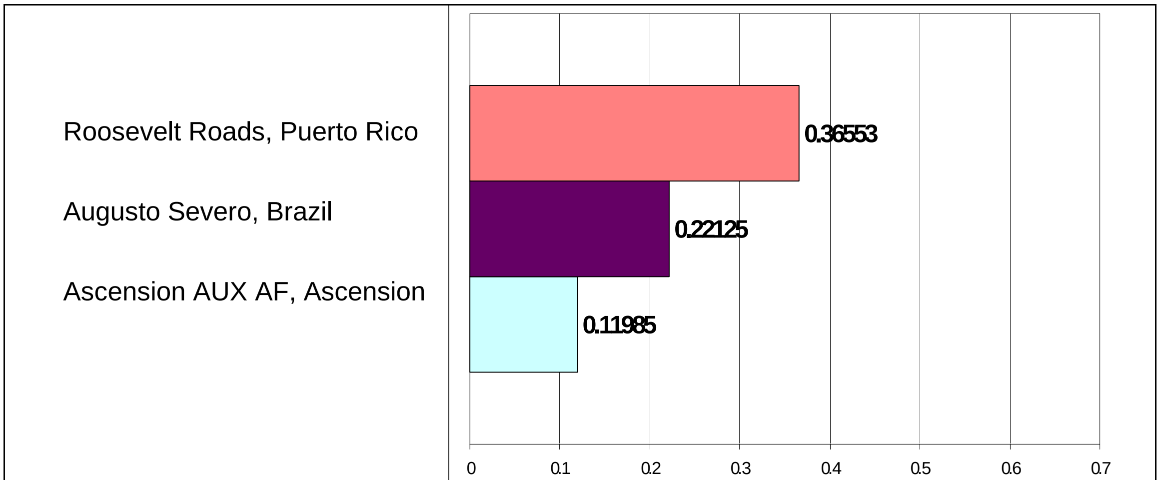
Note: * - the airfield is not ranked in the top five for the associated experiment.

Western Africa showed the most differences between the experiments. First; Roosevelt Roads, Puerto Rico rises to the most preferred en route base for Monrovia, Liberia. Second; Ramstein AB, Germany and Moron AB, Spain are both eliminated from the top five while Lajes, Portugal and Dakar, Senegal both become top five en route bases for Western Africa. These results are a good example of how the combination of changing preferences and ideas can change the model results and potentially the final decision.

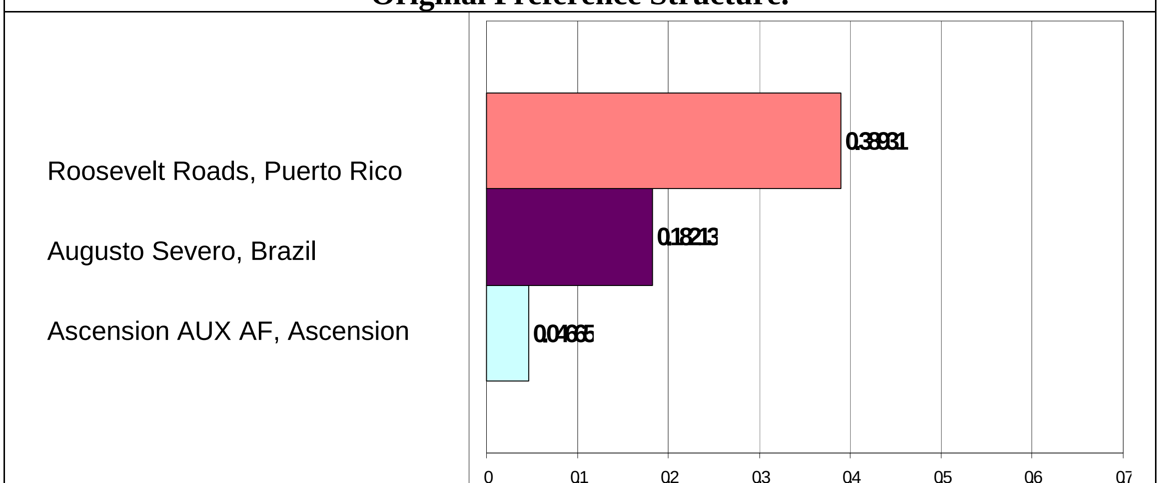
Destination 8. Southern South America (Bahia Blanca, Argentina)

Table 4.40 below shows a comparison of the results between the original preference structure and Experiment Three for Bahia Blanca, Argentina.

Table 4.40. Comparison of Original Model and Experiment 3 for South America.



Original Preference Structure.



Adjusted Preference Structure and Weighted CONUS Origins.

The results for Argentina, as expected, do not change. The limited number of feasible alternatives reduces the affect of the preference structure. However; Roosevelt Roads, Puerto Rico remains the most preferred en route base for Bahia Blanca, Argentina suggesting this is an optimal airfield for Southern South America.

In summary, many changes occur in Experiment Three including the reordering of preferred bases and the inclusion of new bases in the top five. The low number of variations in the results suggests that, for the origin-destination pairs evaluated in this research, the model is robust.

In running the model, a comparison to previous research, and three experiments; several minor changes occur in the preferred list of en route bases. Bases were reordered and a few new bases were included, but the majority of the destinations experienced very little variation in their associated top five en route bases. Baghdad International, Iraq shows only show only changes in the ranking of the same five en route bases; RAF Fairford, England; Ramstein AB, Germany; Rota NAS, Spain; Lajes, Portugal; and Moron AB, Spain. Lahore, Pakistan shows no changes to the top five preferred en route bases; RAF Fairford, England; Ramstein AB, Germany; Mildenhall AB, United Kingdom; Spangdahlem AB, Germany; and Constanta, Romania. Dili, Indonesia shows only rank changes to the top five preferred bases; Misawa AB, Japan; Yokota AB, Japan; Thumrait, Oman; Seeb, Oman; and Iwakuni MCAS, Japan. Gao, India shows a change in rank ordering and the inclusion of Iwakuni MCAS, Japan when the preference structure is adjusted. The other four preferred bases are Constanta, Romania; Sigonella AB, Italy; Burgas, Bulgaria; and Incirlik AB, Turkey. Seoul, Republic of Korea shows only minor changes in rank ordering of its preferred bases; Elmendorf AFB, Alaska; Misawa AB, Japan; Yokota AB, Japan; Iwakuni MCAS, Japan; and Andersen AB, Guam. Waterkloof, South Africa shows minor changes in the rank ordering and the inclusion of an additional preferred base. Ali Al Salem, Kuwait rises to the top five while Seeb, Oman drops from the top five when preferences are varied. The remaining preferred bases are

Kotoka, Ghana; Libreville, Gabon; Entebbe, Uganda; and Kuwait International, Kuwait. Monrovia, Liberia shows changes in rank ordering as well as the inclusion of several additional preferred bases. Due to changes in preferences and the additional weight on the CONUS origins Lajes, Portugal and Dakar, Senegal rise to the top five while Ramstein AB, Germany and Moron AB, Spain are no longer in the top five preferred bases. Finally, Bahia Blanca, Argentina shows no changes to the top three preferred en route bases. This results from the reduced number of feasible solutions and the robustness of the preferred en route base; Roosevelt Roads, Puerto Rico.

Scenario: Germany Pulls Political Support of Military Operations to Iraq

This is a hypothetical scenario built to evaluate the ERLS model. The German Prime Minister has just informed the US President that Germany can no longer support military operations to Iraq. The US must now use other airfields as origins for all missions to Southwest Asia. The US Department of State has announced reduced relations with Germany as a political reaction to Germany's announcement. Force Protection at the base has increased dramatically as tensions in the country rise. German citizens are assembling outside the bases in Germany to protest the war in Iraq. Thus, US troops have been moved on-base to reduce the potential danger from the protesters and to ensure availability for missions. The troops are being booked three to a room at accommodate everyone. Troops are not allowed to leave base and so are eating all meals at base provided facilities. The German military's Military Cooperation has not changed dramatically. The German military still has access the bases and continues to support the US missions on a more limited basis. How does this affect the preferred airfield to support operations to Baghdad, Iraq? The factors that are affected by this change in political support are detailed in Table 4.42.

Table 4.42. Factors Affected by Political Changes.

Measure	Previous Level	Current Level
Diplomatic Clearance	Blanket	Limited
Force Protection	Moderate	Complete
Military Cooperation	Excellent	Good
Department of State	Excellent	Poor
Lodging	Adequate	Inadequate
Dining	Adequate	Inadequate

The ERLS model is updated to reflect the pending situation and the results are shown in Table 4.43.

Table 4.43. Comparison of Experiments 1-3 for Germany Scenario.

RAF Fairford, England	RAF Fairford, England
Rota NAS, Spain	Rota NAS, Spain
Lajes, Portugal	Lajes, Portugal
Moron AB, Spain	Moron AB, Spain
Mildenhall AB, United Kingdom	Ramstein AB, Germany
Constanta, Romania	Mildenhall AB, United Kingdom
Sigonella, Italy	Constanta, Romania
Ramstein AB, Germany	Incirlik AB, Turkey
Kotoka, Ghana	Spangdahlem AB, Germany
Burgas, Bulgaria	Burgas, Bulgaria
Original Preference Structure	**Exp 1: Adjusted Preference Structure**
RAF Fairford, England	RAF Fairford, England
Rota NAS, Spain	Rota NAS, Spain
Lajes, Portugal	Lajes, Portugal
Moron AB, Spain	Moron AB, Spain
Mildenhall AB, United Kingdom	Ramstein AB, Germany
Constanta, Romania	Mildenhall AB, United Kingdom
Sigonella, Italy	Constanta, Romania
Ramstein AB, Germany	Incirlik AB, Turkey
Kotoka, Ghana	Spangdahlem AB, Germany
Burgas, Bulgaria	Burgas, Bulgaria
Exp 2: Weighted CONUS Origins	**Exp 3: Experiments 1 and 2 Combined**

The political tensions between the US and Germany have affected the use of Spangdahlem and Ramstein airbases for the conflict in Iraq. The model shows that the changes in relations have also affected the rank of the Germany based airfields. Ramstein AB is originally ranked in the top two airfields for Baghdad, Iraq. The change in relations forces Ramstein AB to drop out of the top five in the original preference structure. Ramstein AB remains in the top five for Experiments One and Three, but drops from second to fifth most preferred. Spangdahlem AB is not in the top five in any of the results. This scenario shows that Host Nations Relations can have a severe affect on the rank order of airfields.

In summary, this chapter has demonstrated how the scores and rankings obtained by each potential en route airfield can yield useful conclusions. There are certain areas of the world where the inclusion of new an en route airfield would be beneficial. From the scores calculated by the ERLS, the best en route is illustrated. Conclusions and recommendations are summarized in the next chapter.

V. Conclusions and Recommendations

Introduction

This chapter presents a summary of the results presented in chapter four and the corresponding conclusions and recommendations.

Table 5.1 summarizes the top two en route bases for each destination.

Table 5.1. Top Two En Route Bases By Destination (Experiment 3).

Destination	Top Two En Route Bases
Baghdad International, Iraq	RAF Fairford, England Lajes, Portugal
Lahore, Pakistan	RAF Fairford, England Ramstein AB, Germany
Dili, Indonesia	Misawa AB, Japan Thumrait, Oman
Gao, India	Sigonella, Italy Constanta, Romania
Seoul, Republic of Korea	Elmendorf AFB, Alaska Yokota AB, Japan
Waterkloof, South Africa	Kotoka, Ghana Libreville, Gabon
Monrovia, Liberia	Roosevelt Roads, Puerto Rico RAF Fairford, England
Bahia Blanca, Argentina	Roosevelt Roads, Puerto Rico Augusto Severo, Brazil

Table 5.1 shows six of eight destinations have a current ERS base ranked one or two in the results. However; Gao, India; Waterkloof, South Africa; and Bahia Blanca, Argentina do not have a current ERS base in the top two. Inspection of the results shows no current ERS airfield is in the top ten for these three destinations. However, these destinations have five bases in common within the top ten results. These bases are Ali Al Salem, Kuwait; Ascension AUX AF, Ascension; Bahrain International, Bahrain; Kuwait International, Kuwait; and Seeb, Oman. Each base improves access to two regions but

not to all three regions. Thus, to expand access to these destinations with the en route bases evaluated in this research, two new bases would need to be developed. Of these five bases, Seeb, Oman is also a feasible en route base for several other destinations such as; Baghdad International, Iraq; Lahore, Pakistan; and Dili, Indonesia. Seeb, Oman can be an en route base for two regions currently not supported by the ERS and also provide further support to other destinations. Given the changing political climate in each of these areas; Seeb, Oman is a potential addition to the ERS.

The US military is reaching further around the globe that ever before and the current ERS is not efficient in supporting this expanding role. The potential en route airfields illuminated in this study are candidates to create the global ERS mandatory for success of the US military.

Future Research

This research examined 25 potential airfields under consideration by USTRANSCOM and their potential effectiveness in supporting the GWOT as additional en routes for strategic airlift aircraft. Using the ERLS developed in this study; these airfields were analyzed based on multiple origins and destinations. The best potential en routes and their sensitivity to decision maker preferences were then presented and compared to previous research. The next course of action is to obtain the USTRANSCOM preferences to incorporate into the model. Other future research could focus on model enhancements such as:

1) Construct an interface to create a user friendly model for USTRANSCOM.

2) Incorporate risk or uncertainty into the model to account for factors, such as Diplomatic Clearance and Department of State that are not deterministic.

3) Expand the model to consider en routes based on multiple stops rather than the single stops analyzed here.

4) Incorporate the affects of airfield upgrades such as increased MOG, improved fuel availability and improved ground transportation.

5) Identify optimal en route locations to service multiple origin-destination pairs.

6) Identify an optimal network of en route airfields.

Finally, the ERS must be the foundation of the US military as it operates around the world. This research showed several areas with limited access and their potential en route bases. These bases can enhance the ERS and its ability to support sustained US military missions in today's fast-paced environment.

Appendix A. Alternate Airfields

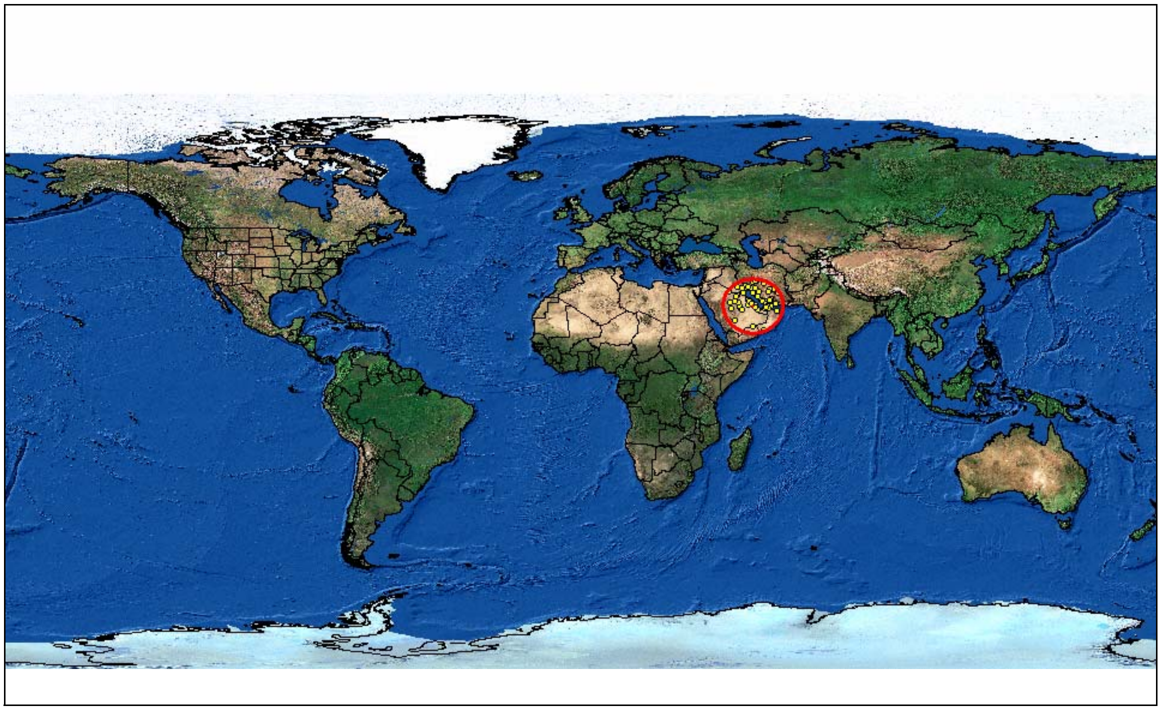


Figure 1. Al Udeid AB, Qatar.

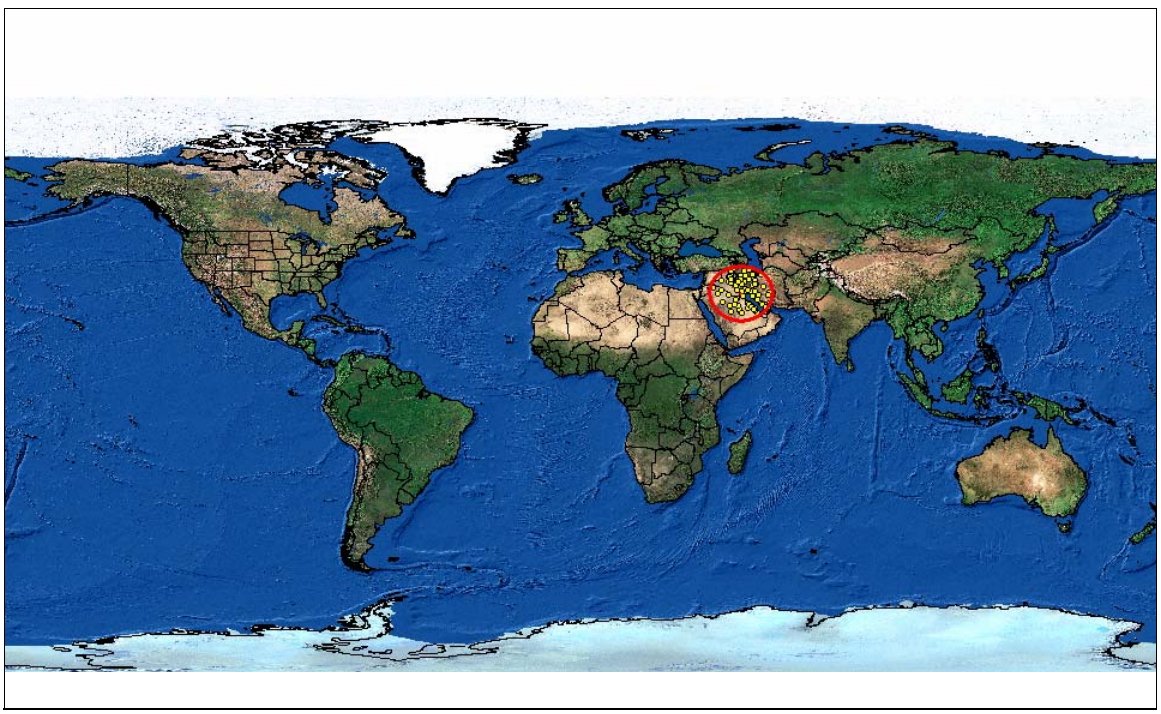


Figure 2. Ali Al Salem, Kuwait.

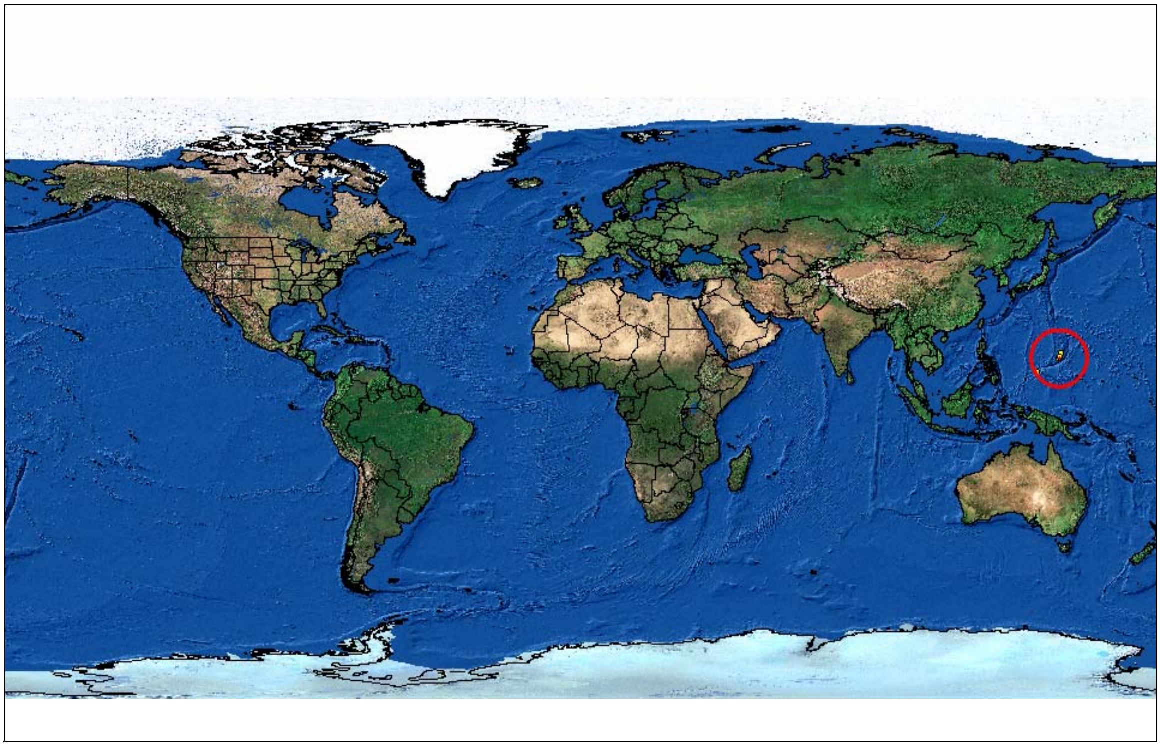


Figure 3. Andersen AB, Guam.

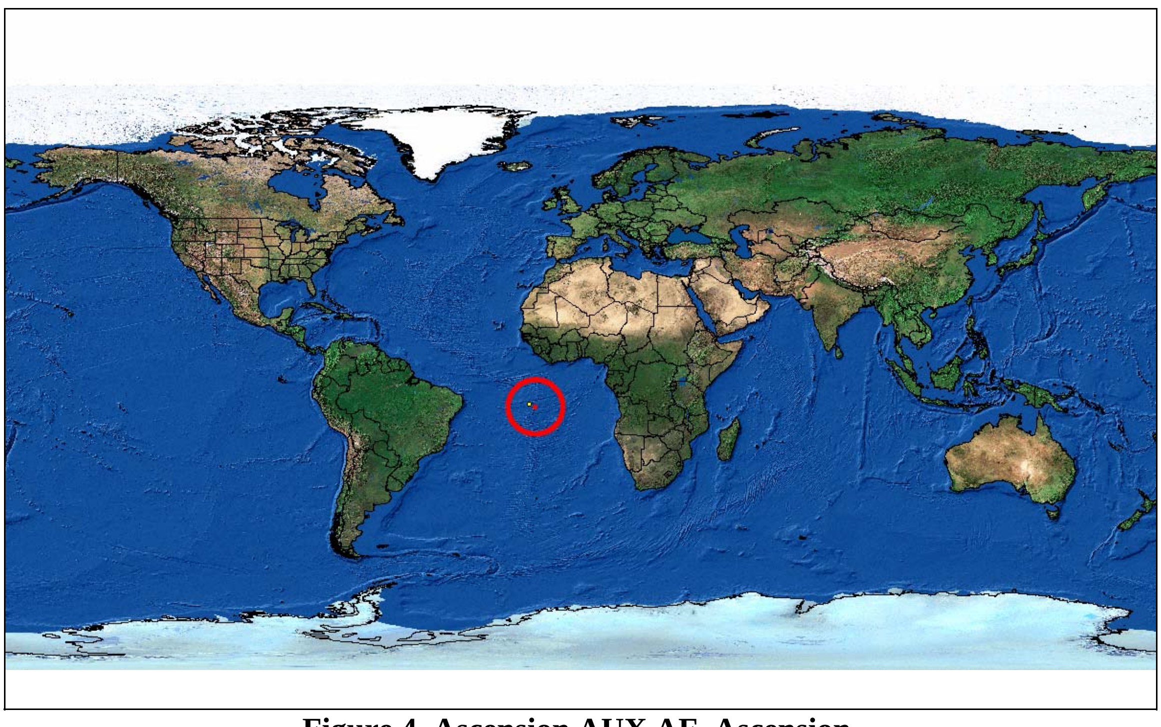


Figure 4. Ascension AUX AF, Ascension.

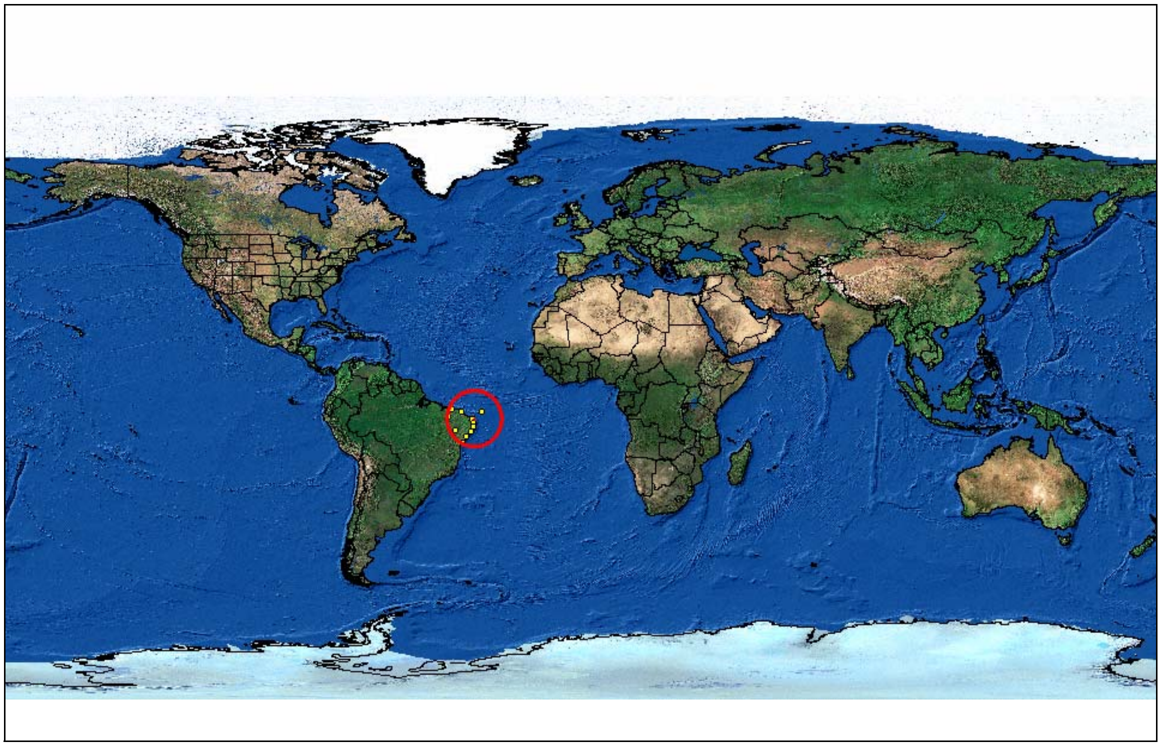


Figure 5. Augusto Severo, Brazil.

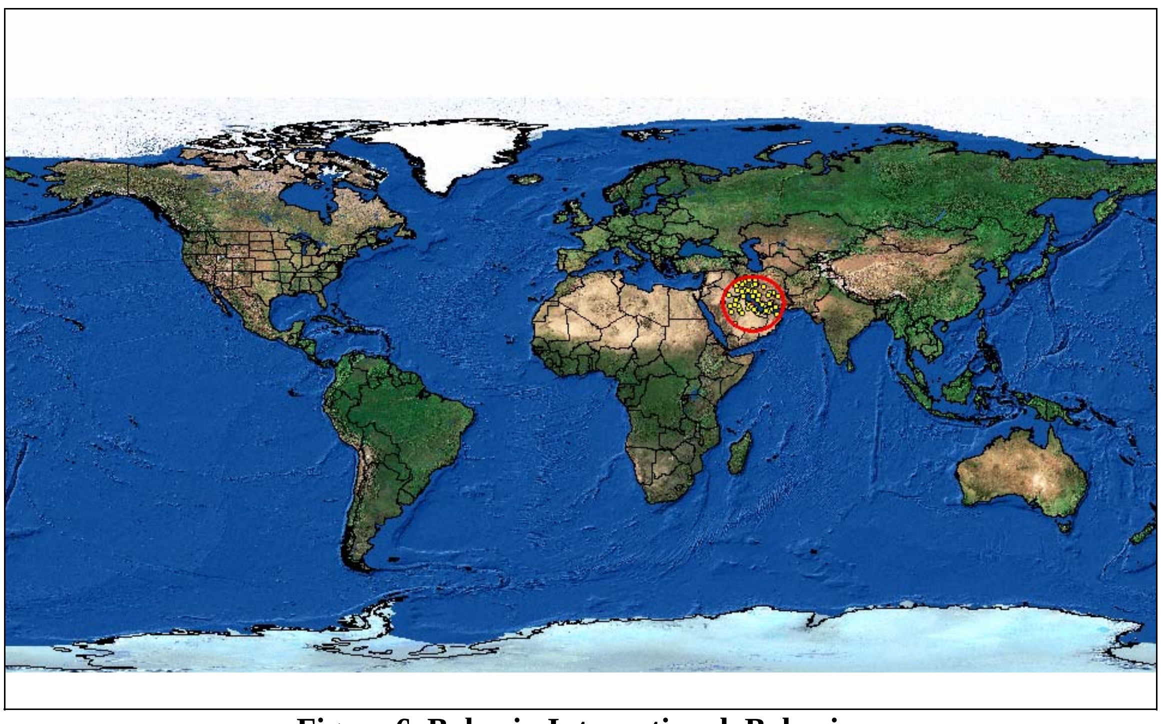


Figure 6. Bahrain International, Bahrain.

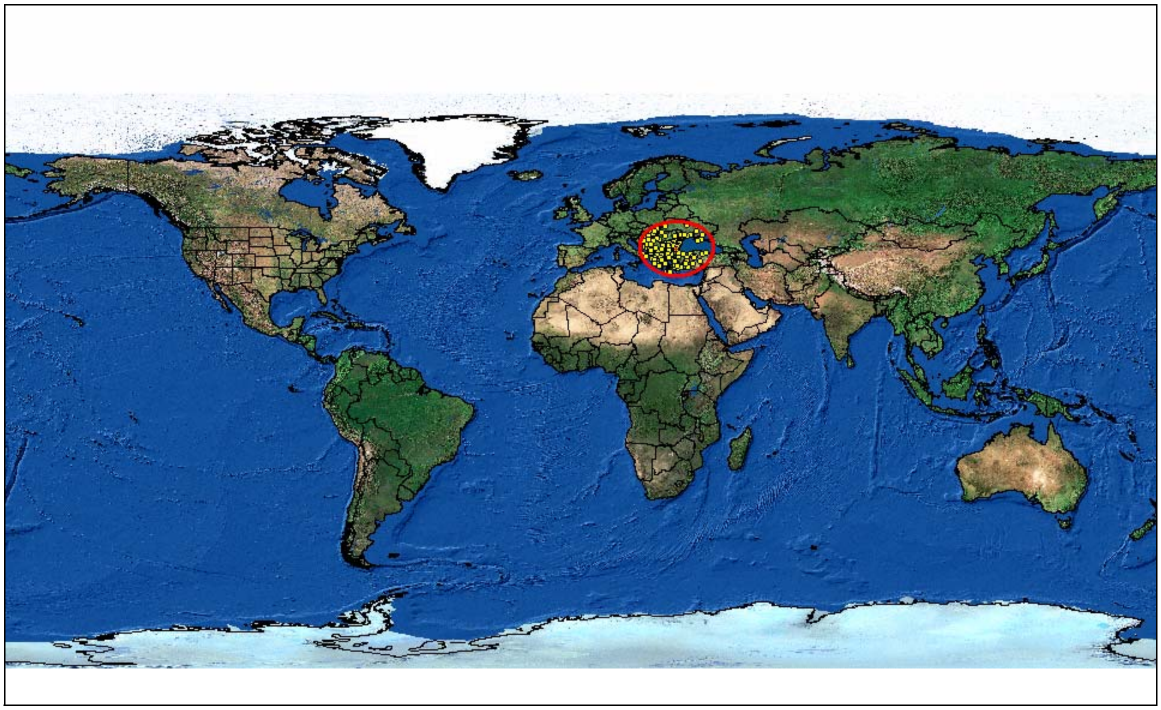


Figure 7. Burgas, Bulgaria.

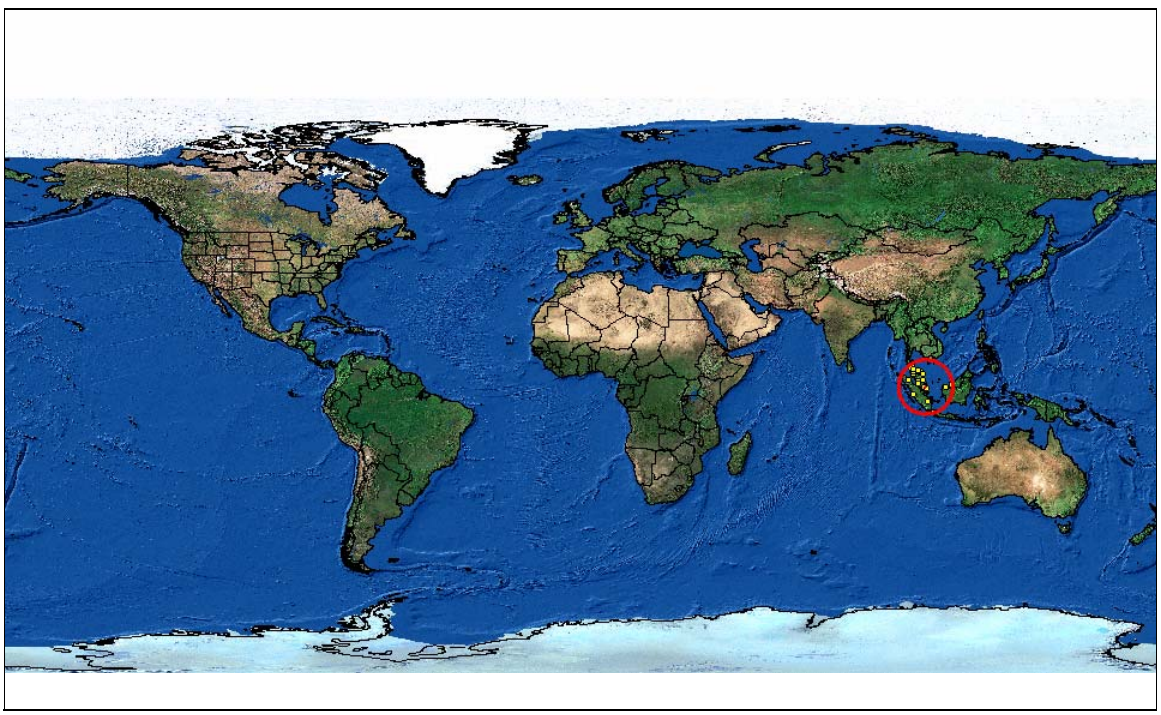


Figure 8. Changi, Singapore.

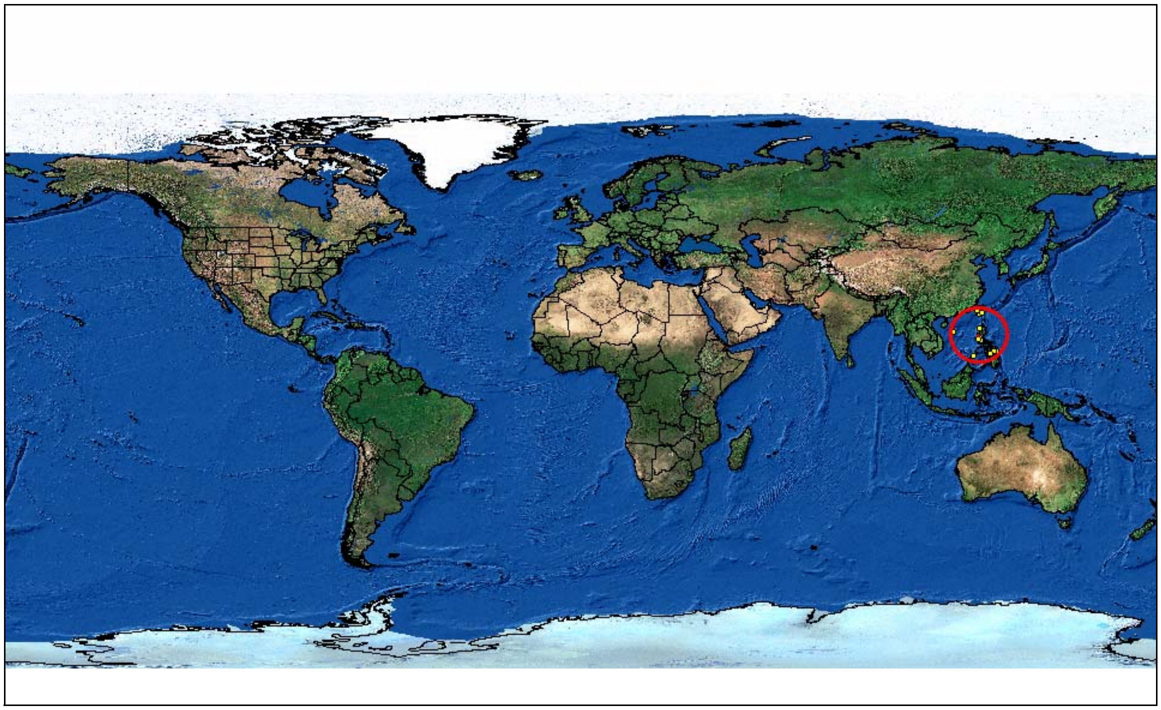


Figure 9. Clark AB, Philippines.

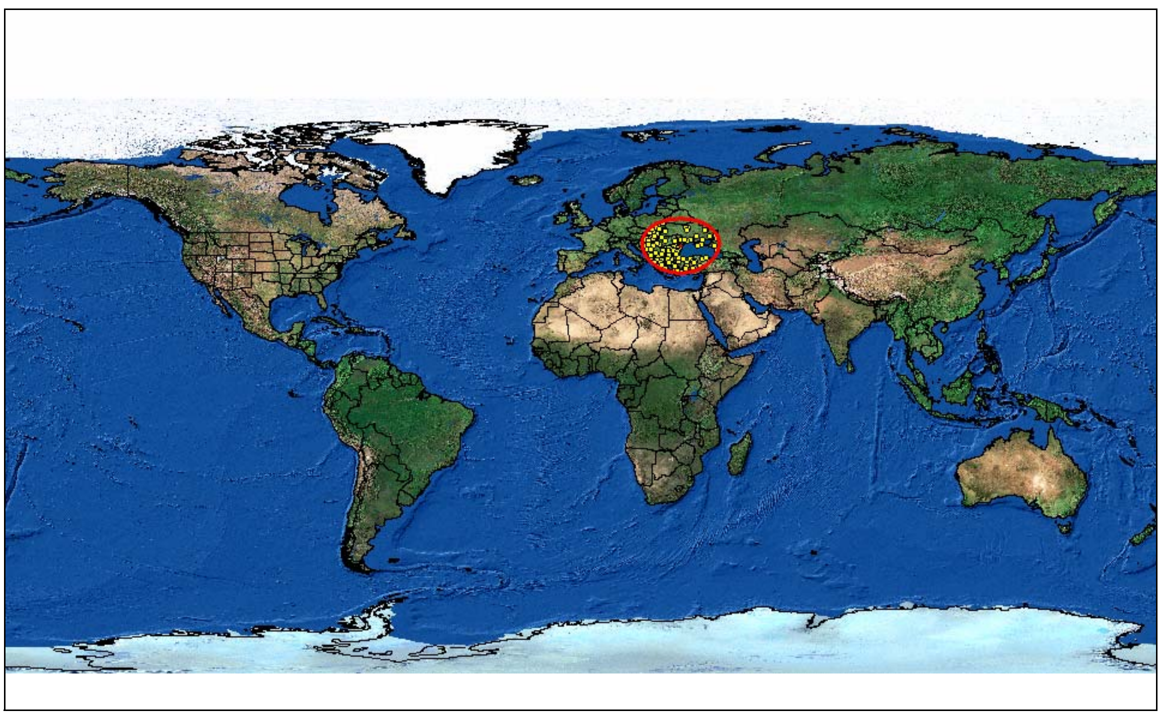


Figure 10. Constanta, Romania.

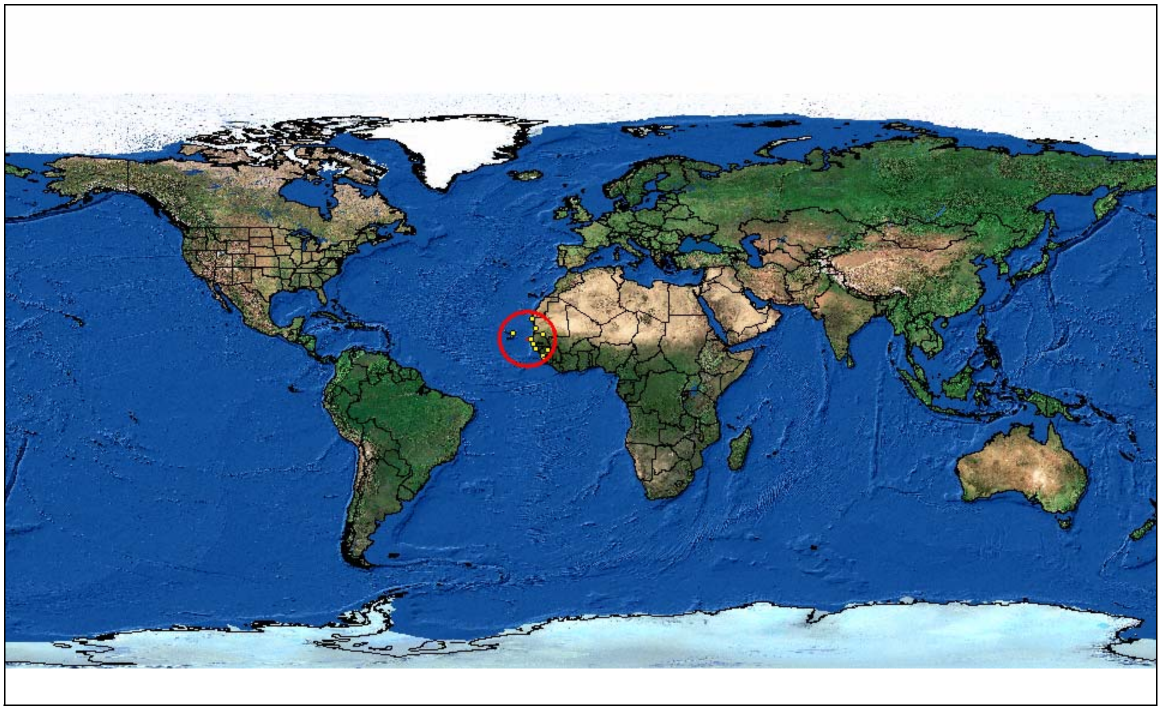


Figure 11. Dakar, Senegal.

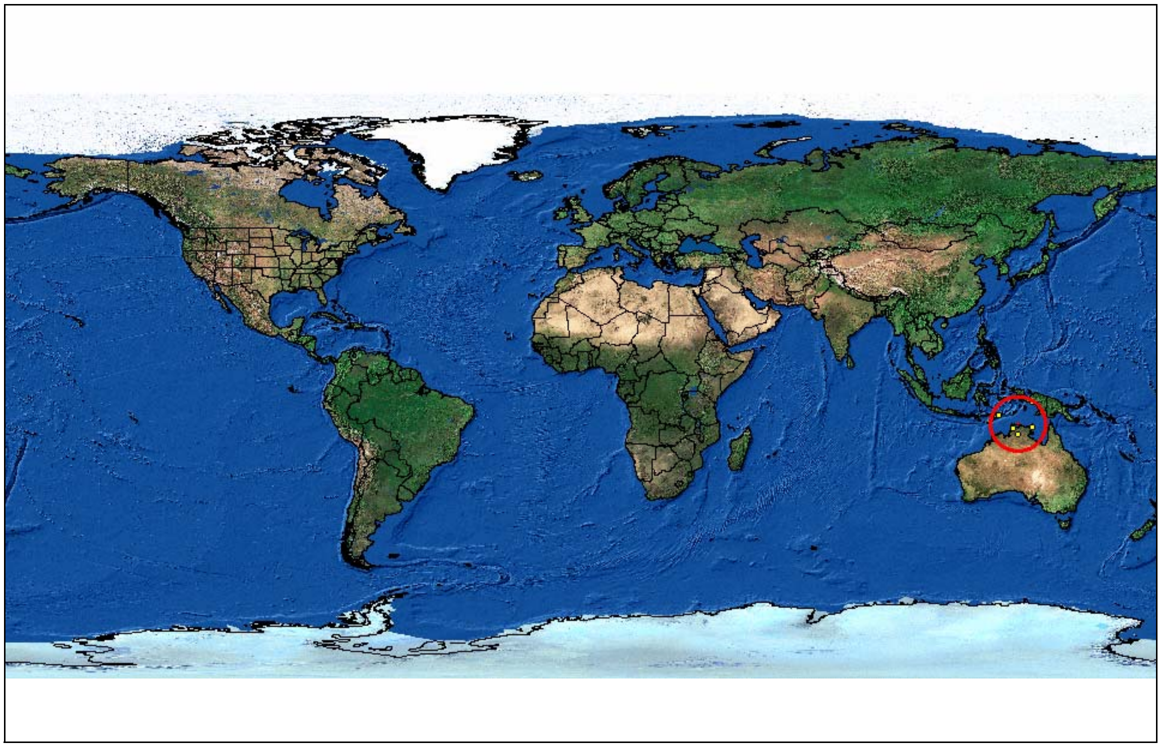


Figure 12. Darwin, Australia.

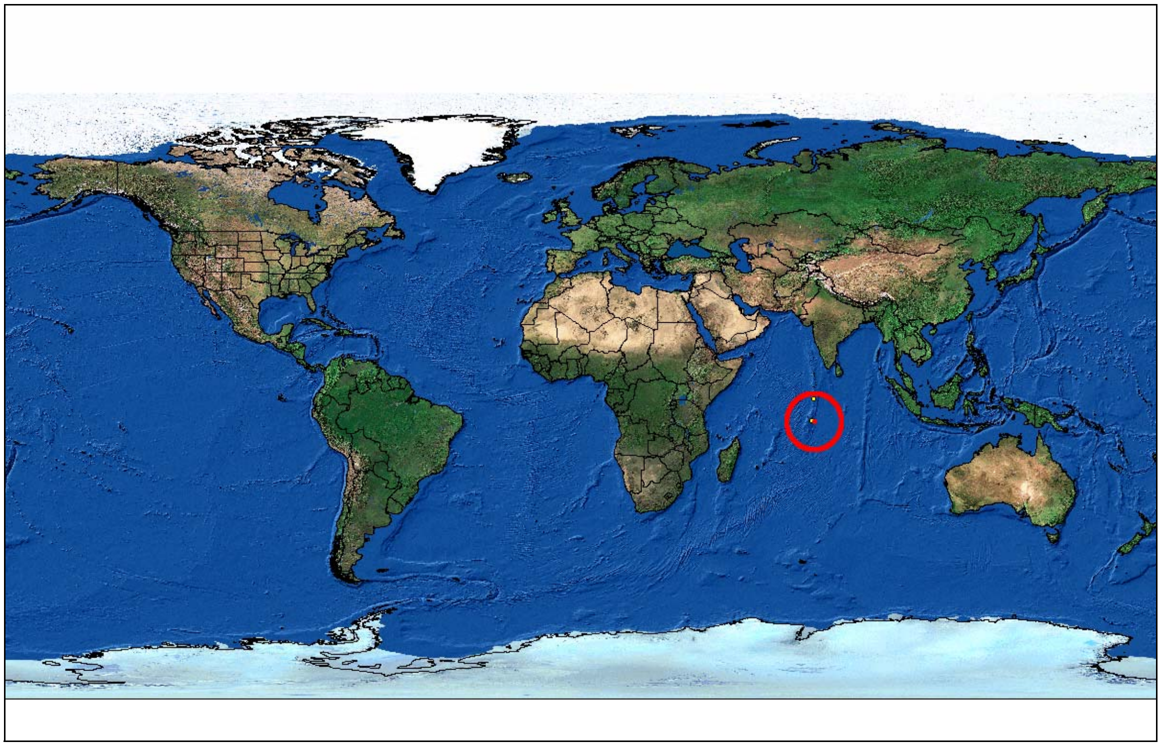


Figure 13. Diego Garcia, British Indian Ocean Territory.

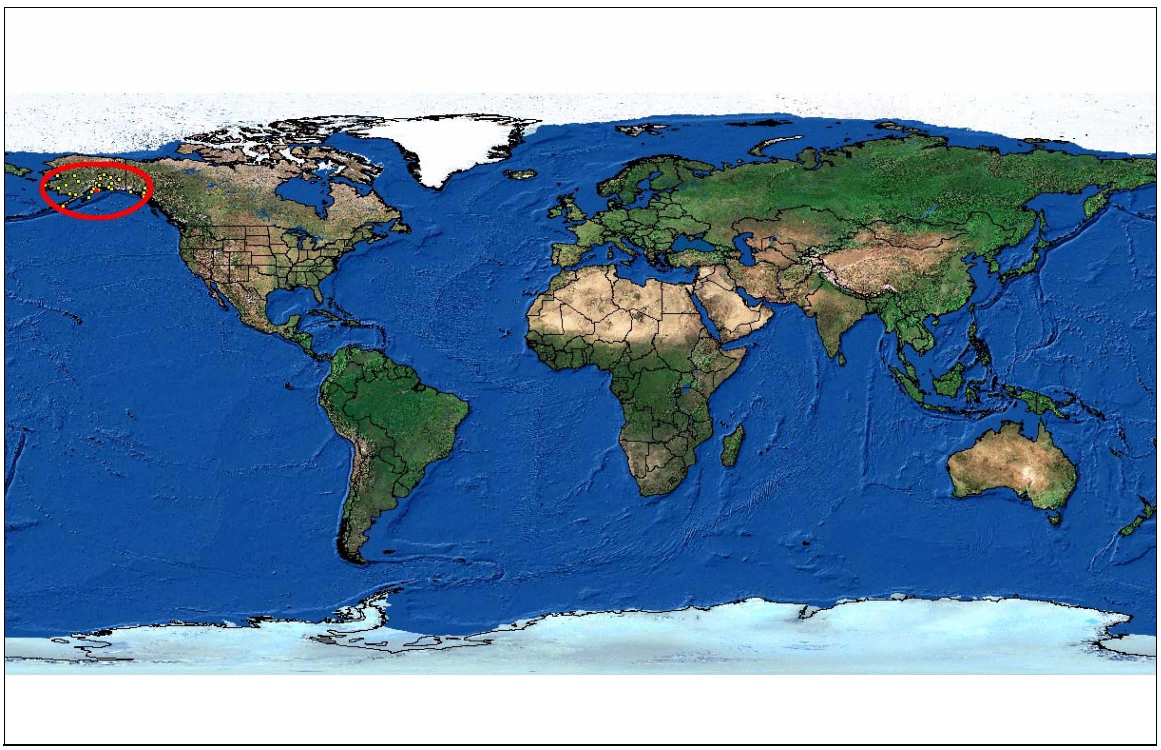


Figure 14. Elmendorf AFB, Alaska.

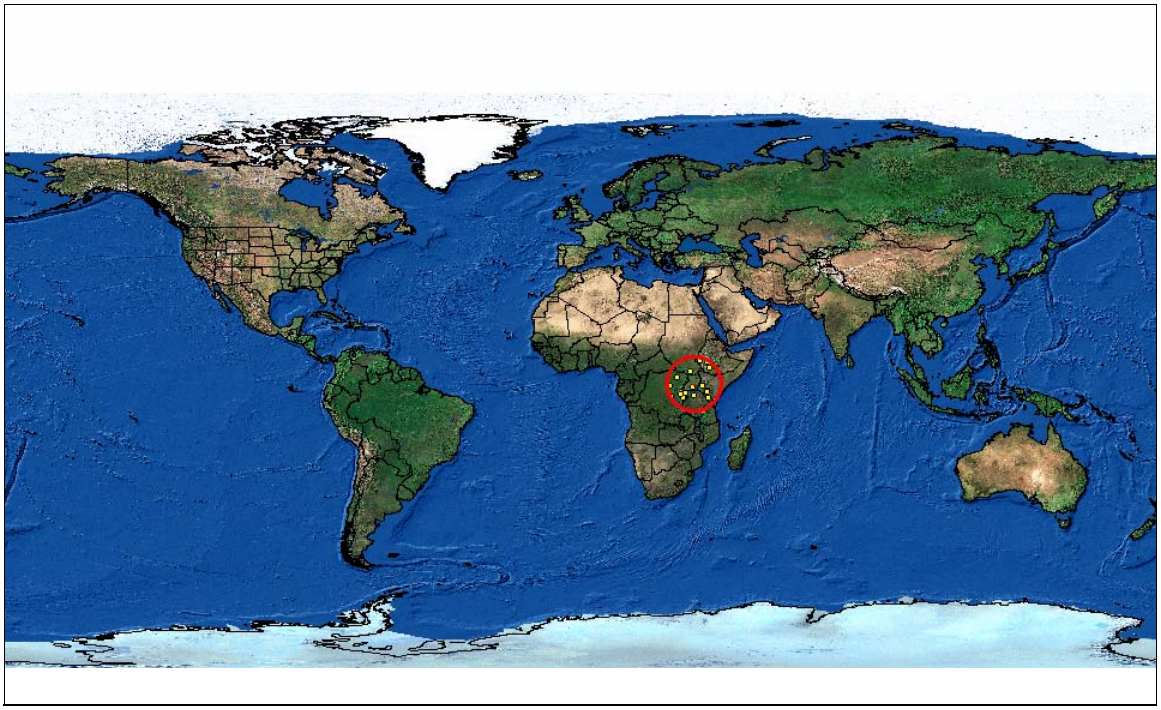


Figure 15. Entebbe, Uganda.

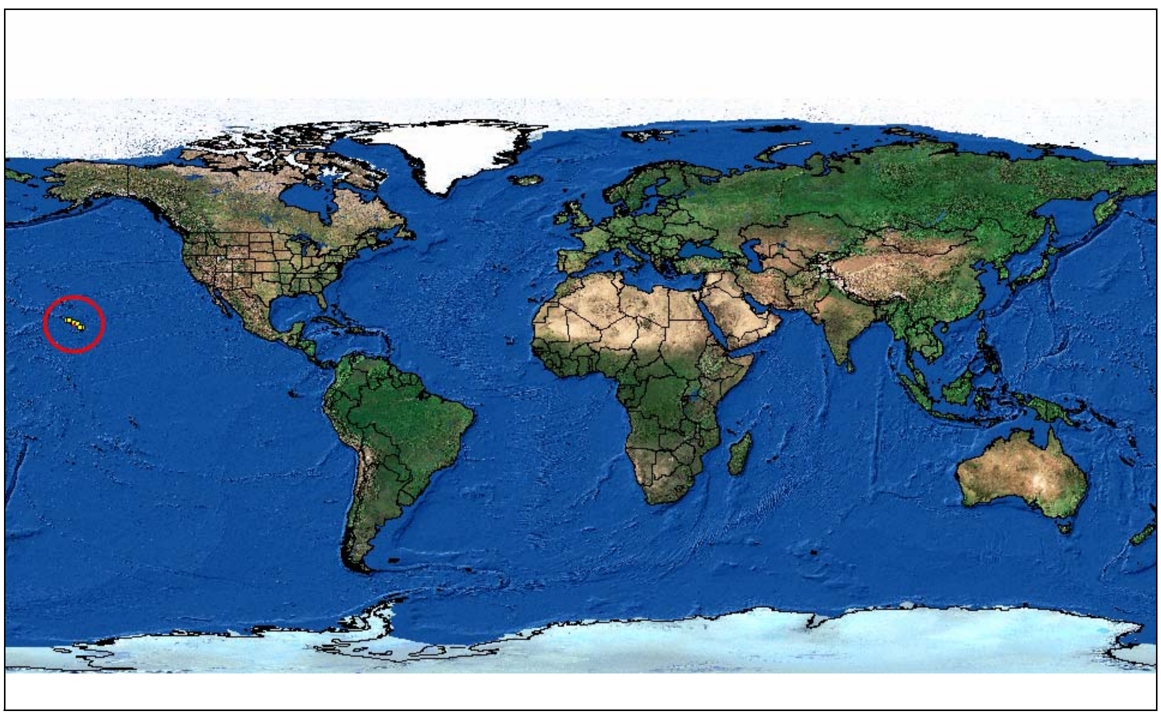


Figure 16. Hickam AFB, Hawaii.

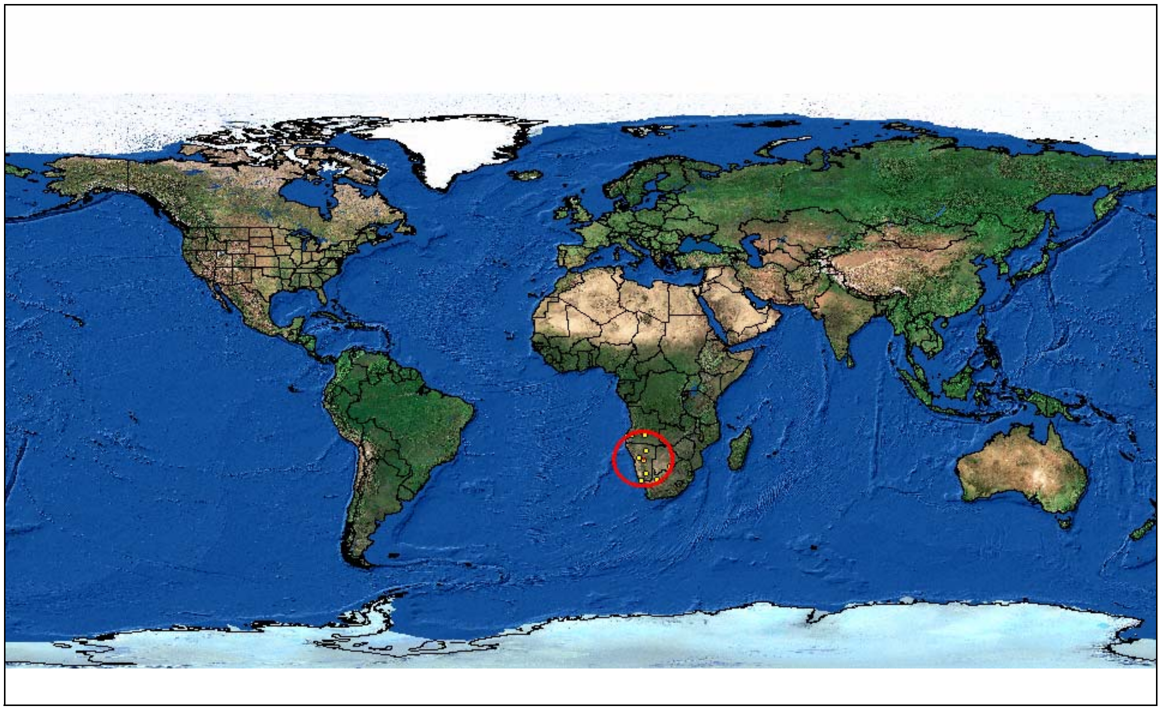


Figure 17. Hosea Kutako, Namibia.

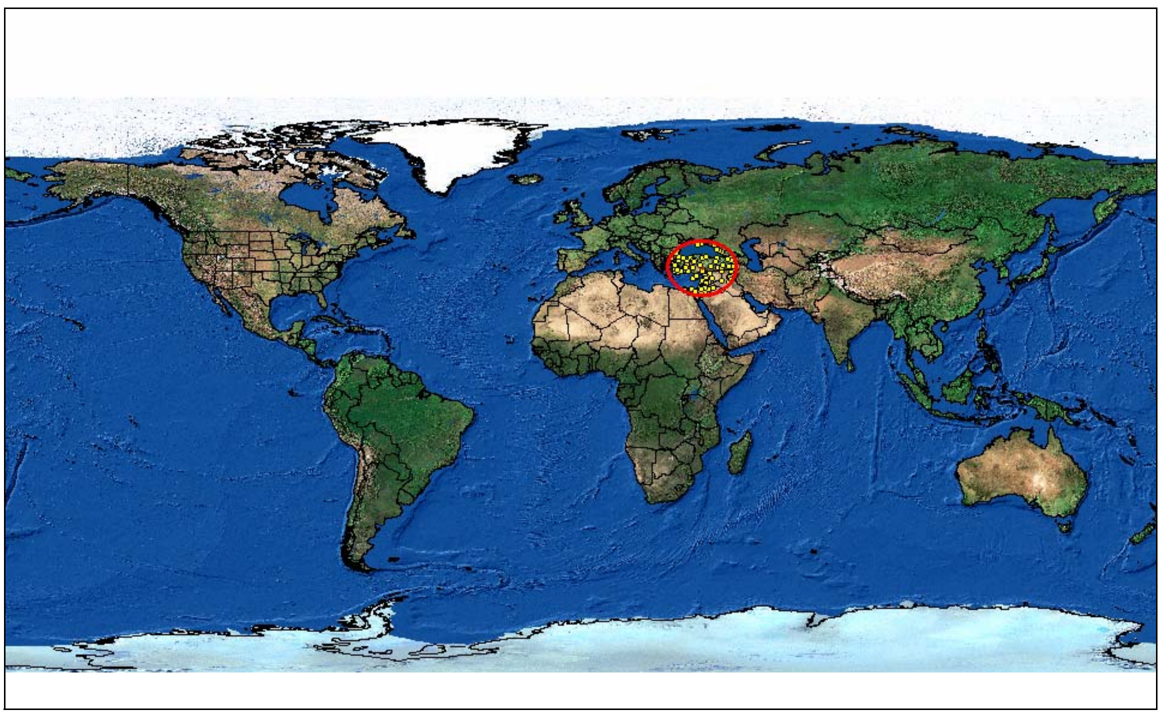


Figure 18. Incirlik AB, Turkey.

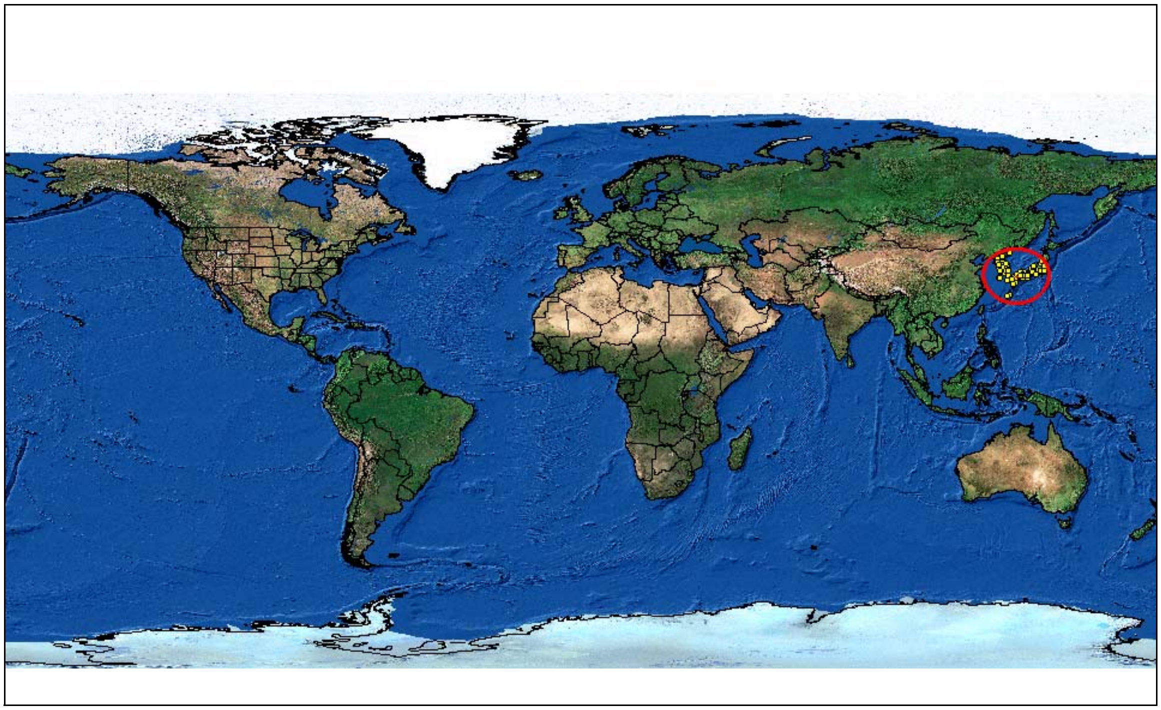


Figure 19. Iwakuni MCAS, Japan.

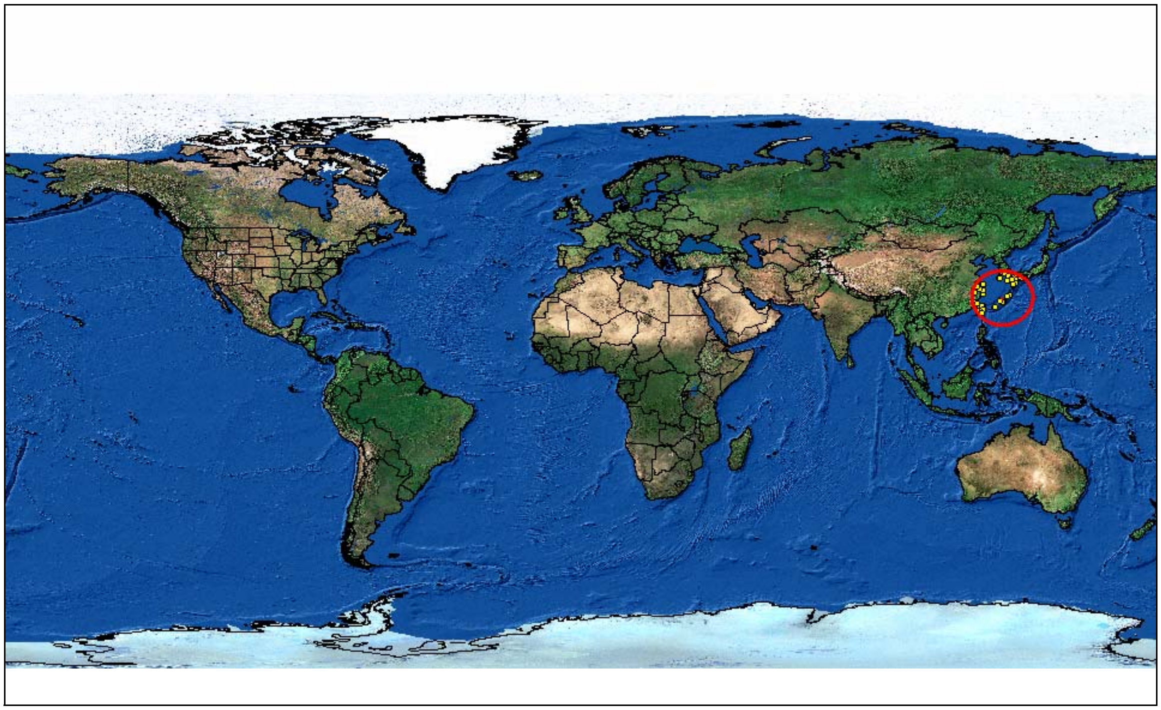


Figure 20. Kadena AB, Japan.

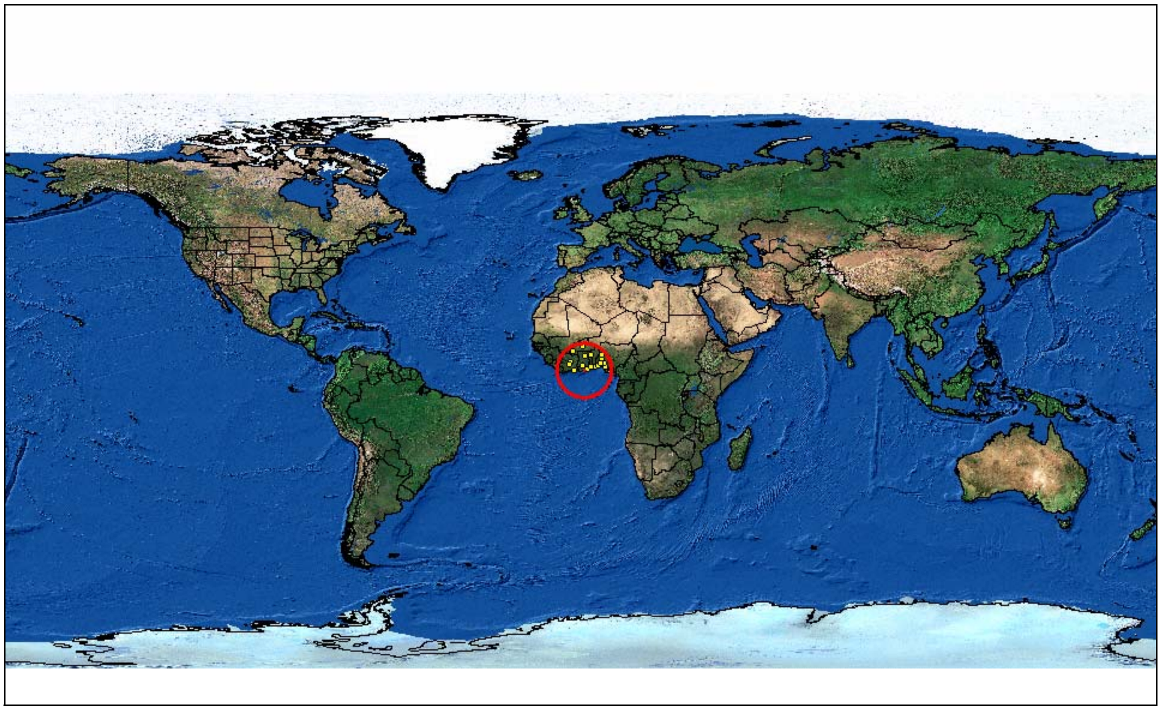


Figure 21. Kotoka, Ghana.

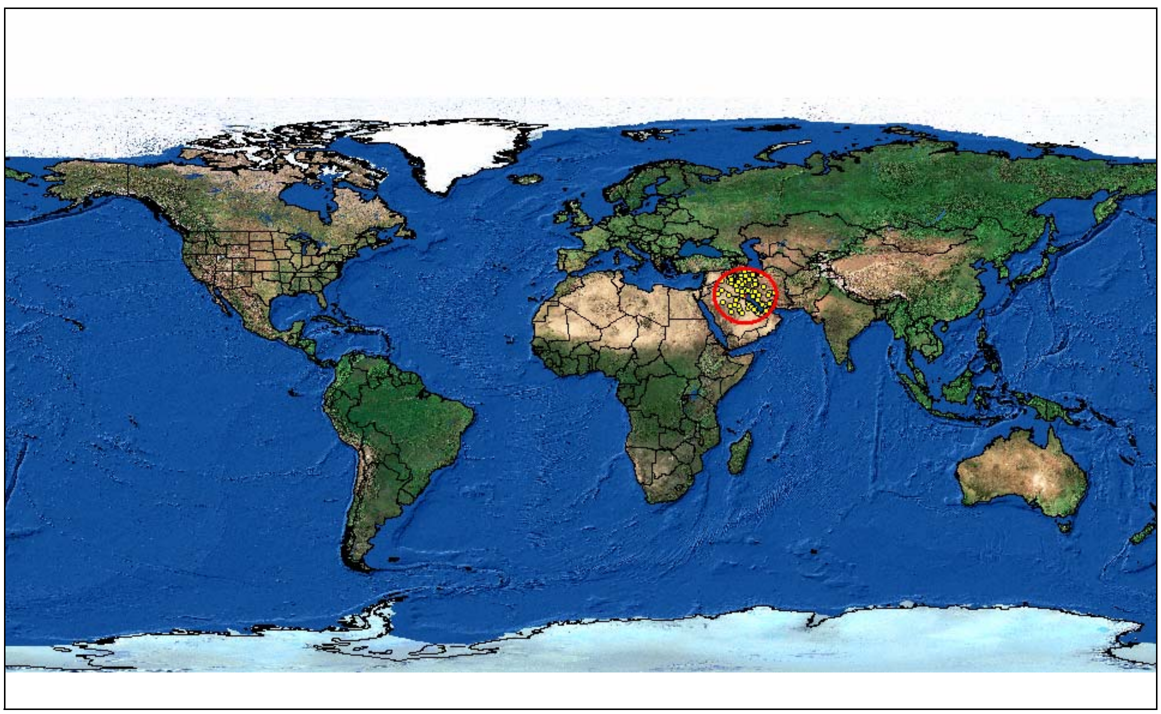


Figure 22. Kuwait International, Kuwait.

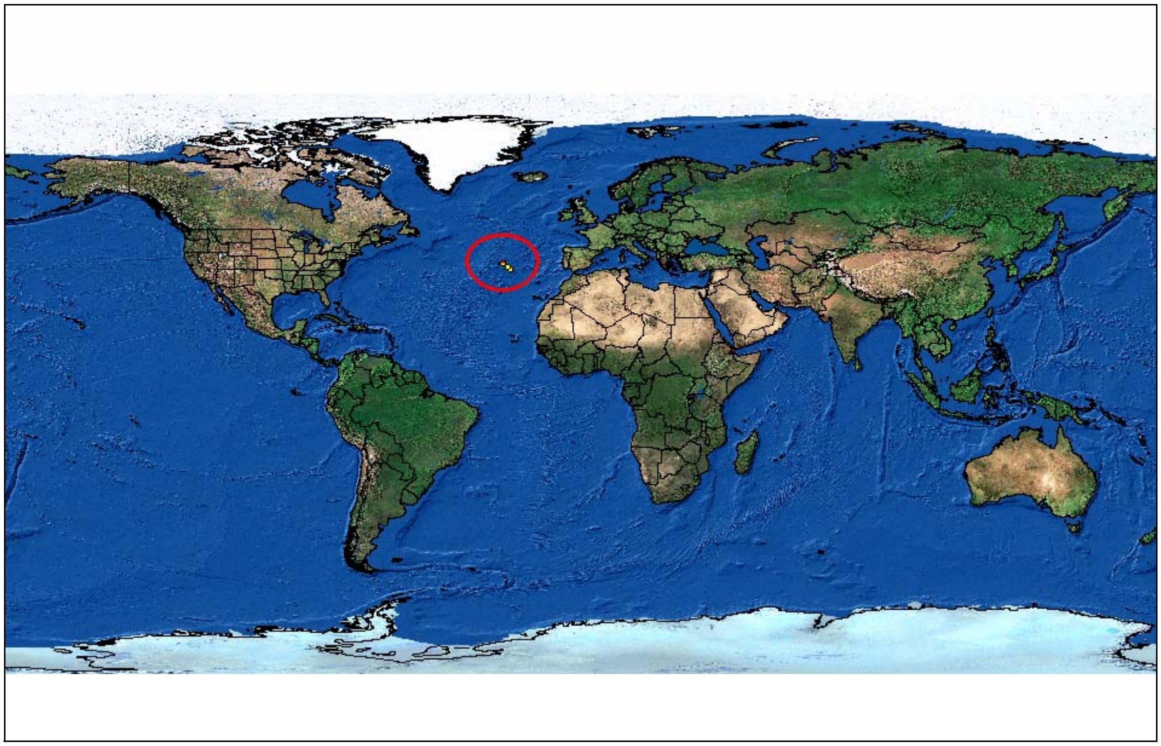


Figure 23. Lajes, Portugal.

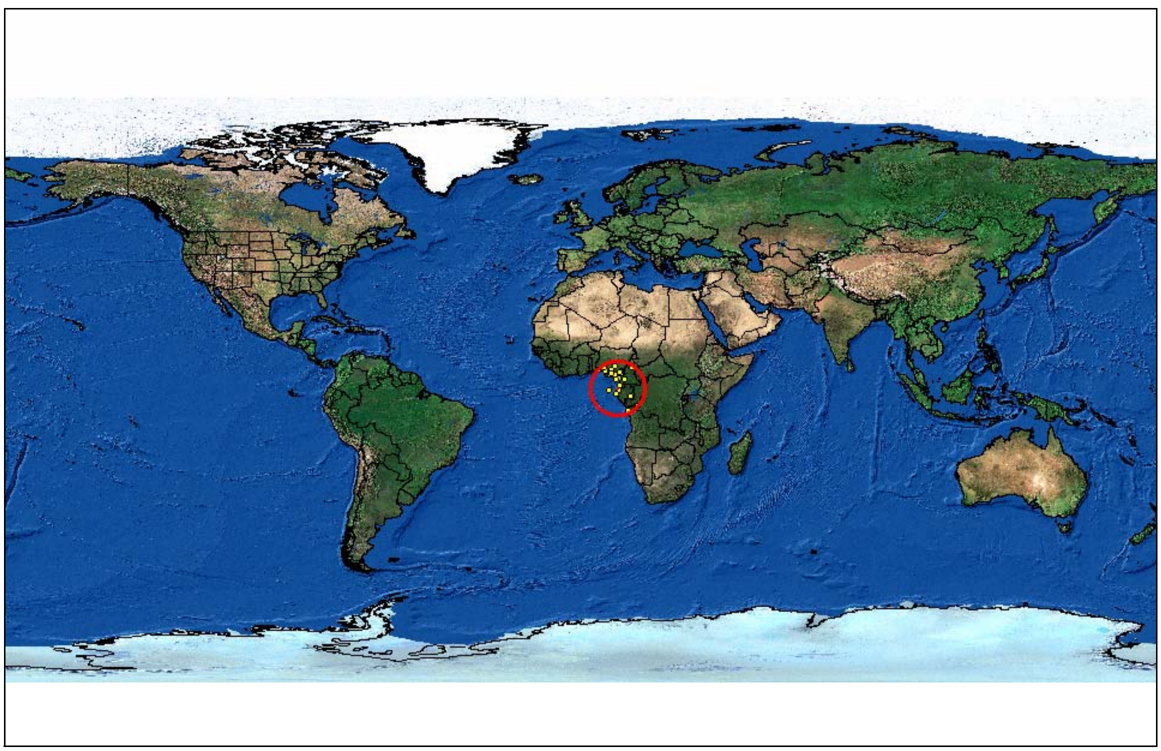


Figure 24. Libreville, Gabon.

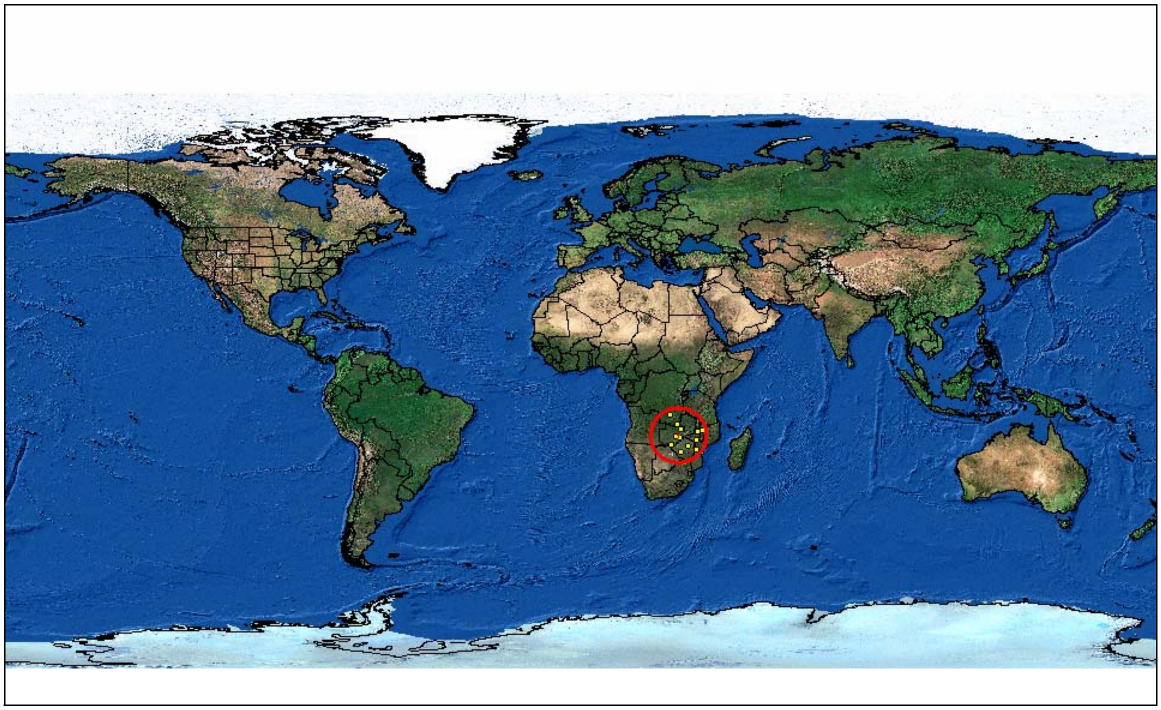


Figure 25. Lusaka, Zambia.

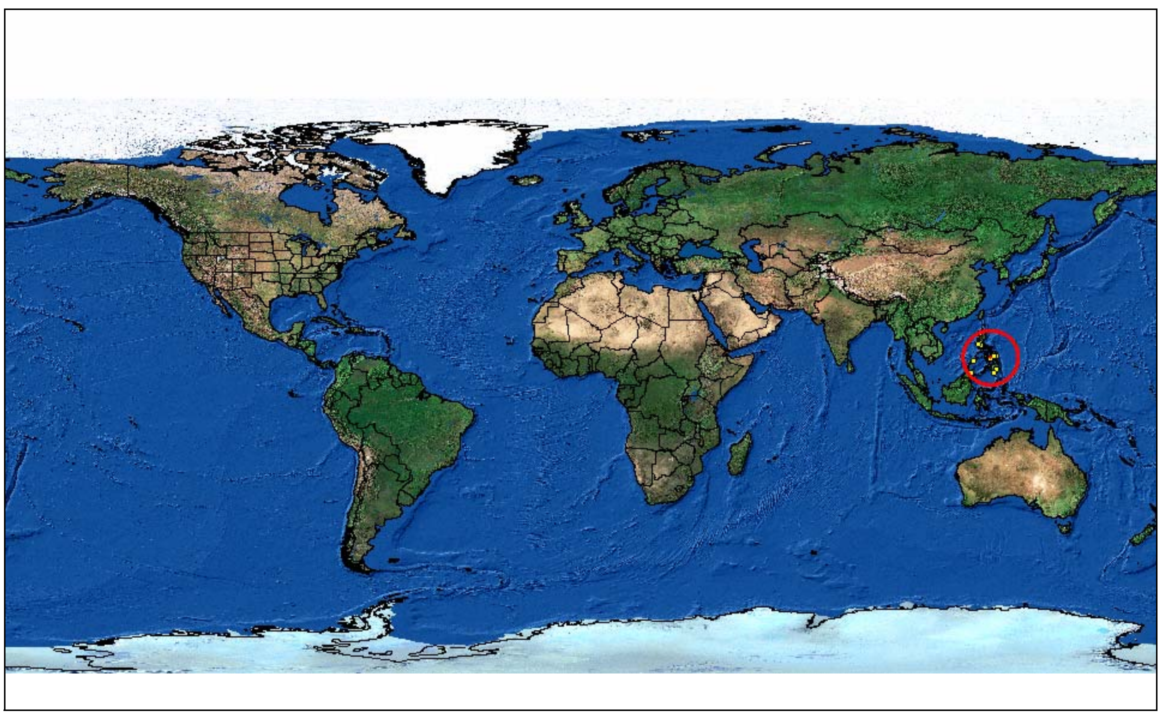


Figure 26. Mactan International, Philippines.

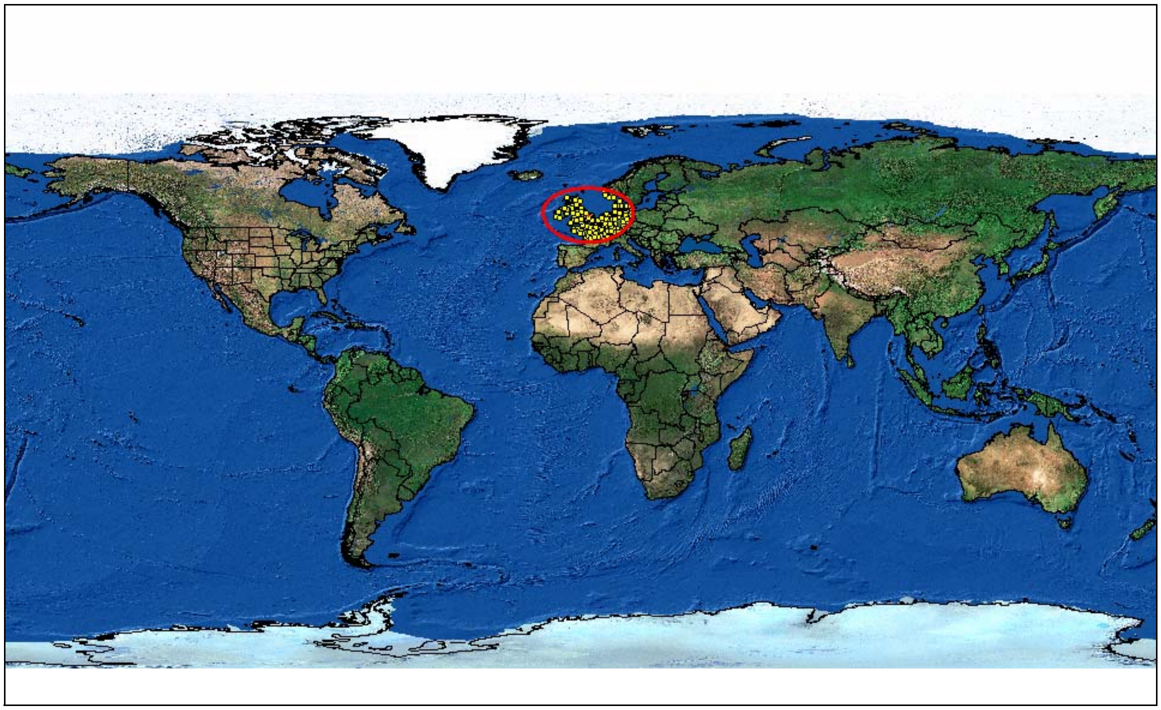


Figure 27. Mildenhall AB, United Kingdom.

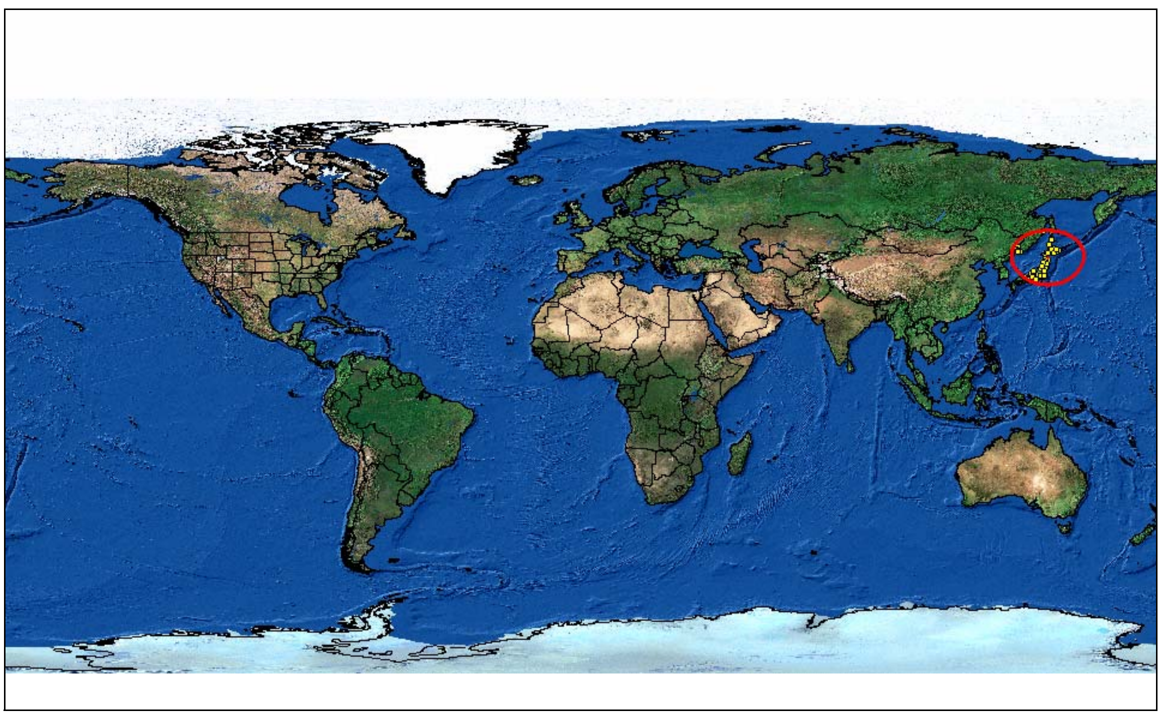


Figure 28. Misawa AB, Japan.

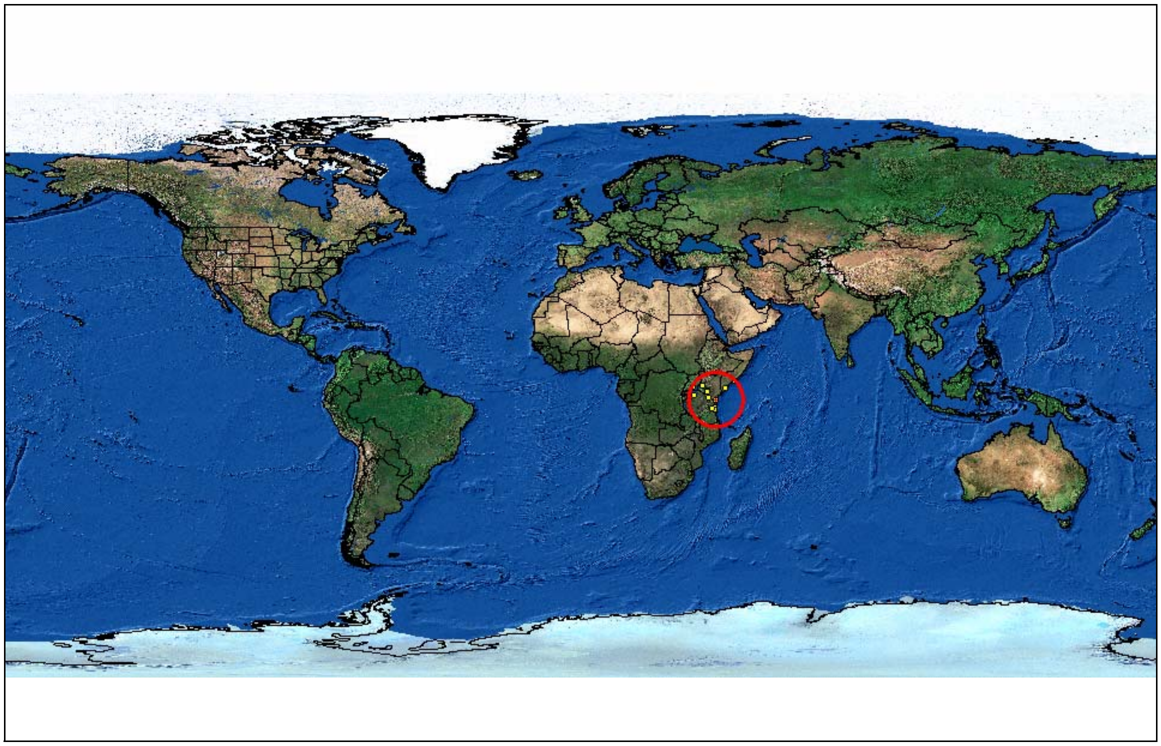


Figure 29. Moi, Kenya.

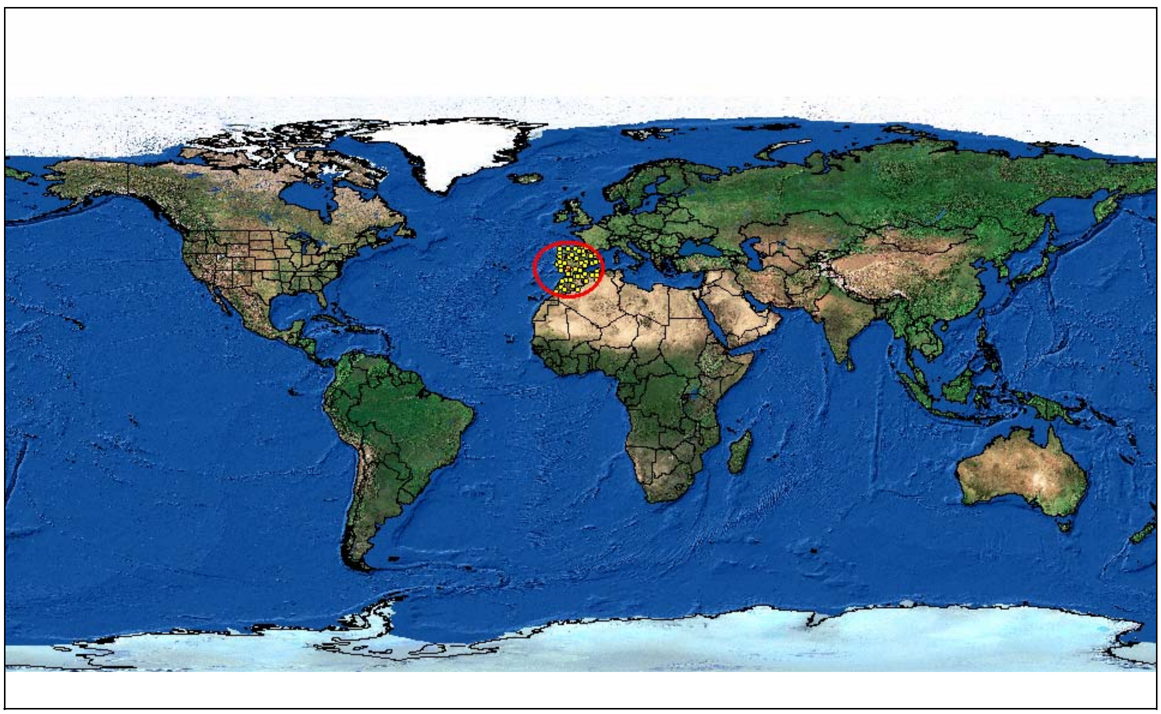


Figure 30. Moron AB, Spain.

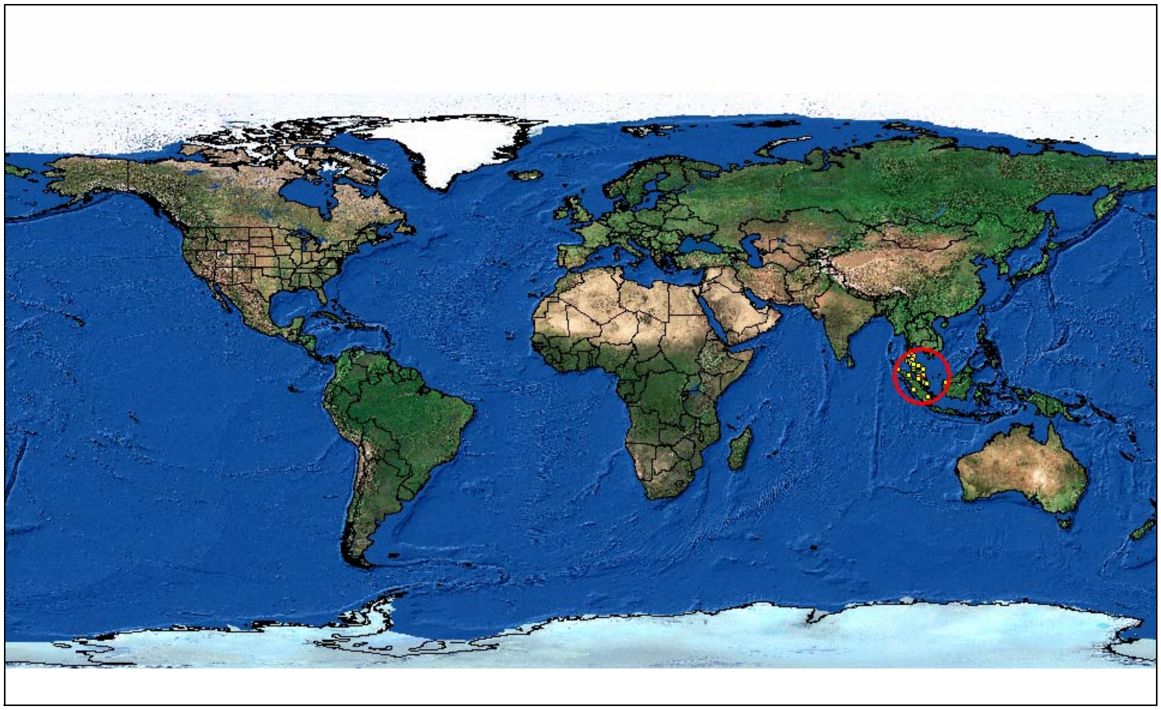


Figure 31. Paya Lebar, Singapore.

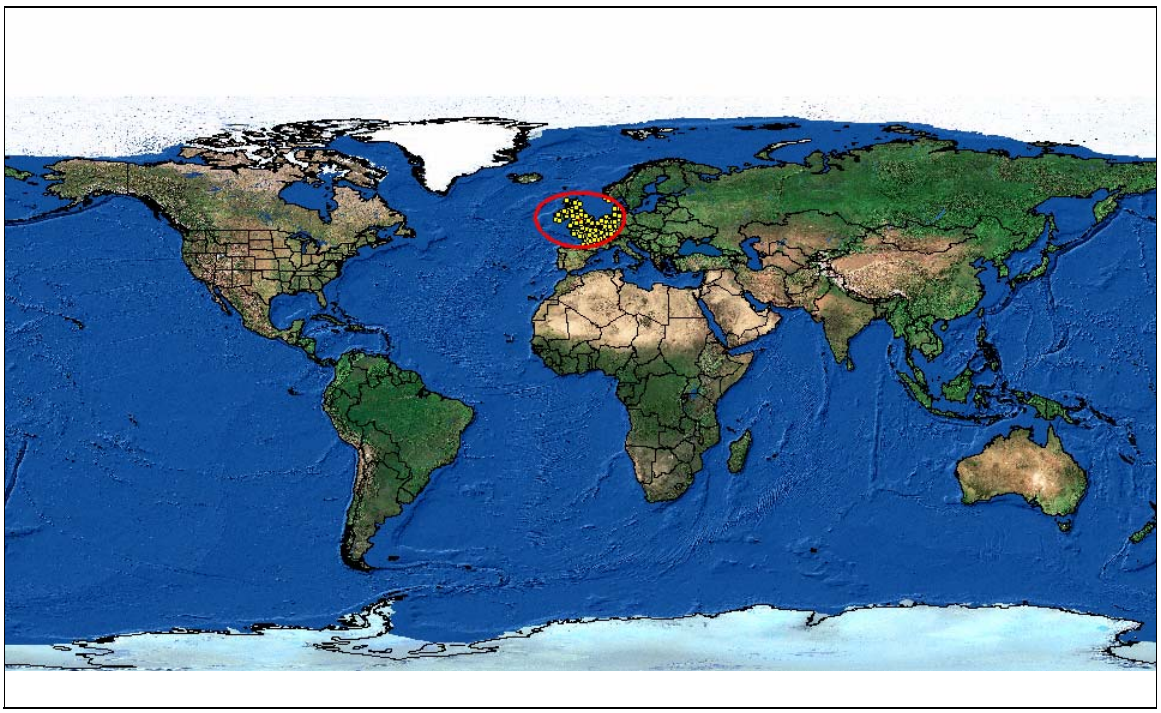


Figure 32. RAF Fairford, England.

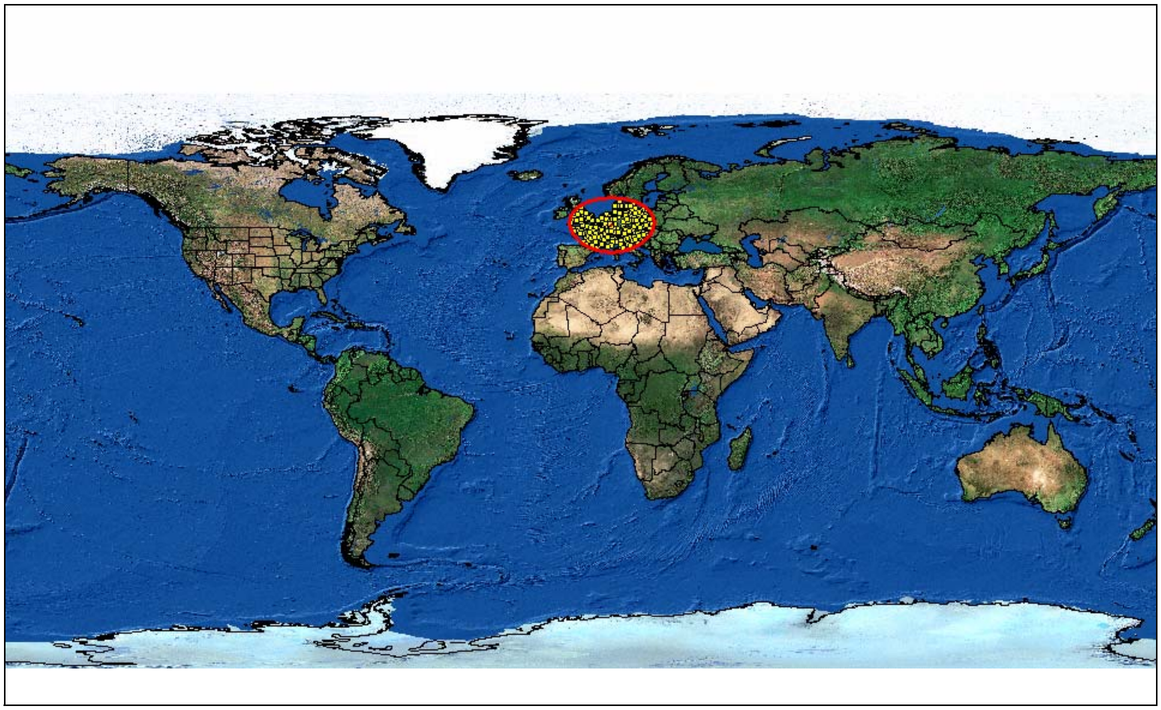


Figure 33. Ramstein AB, Germany.

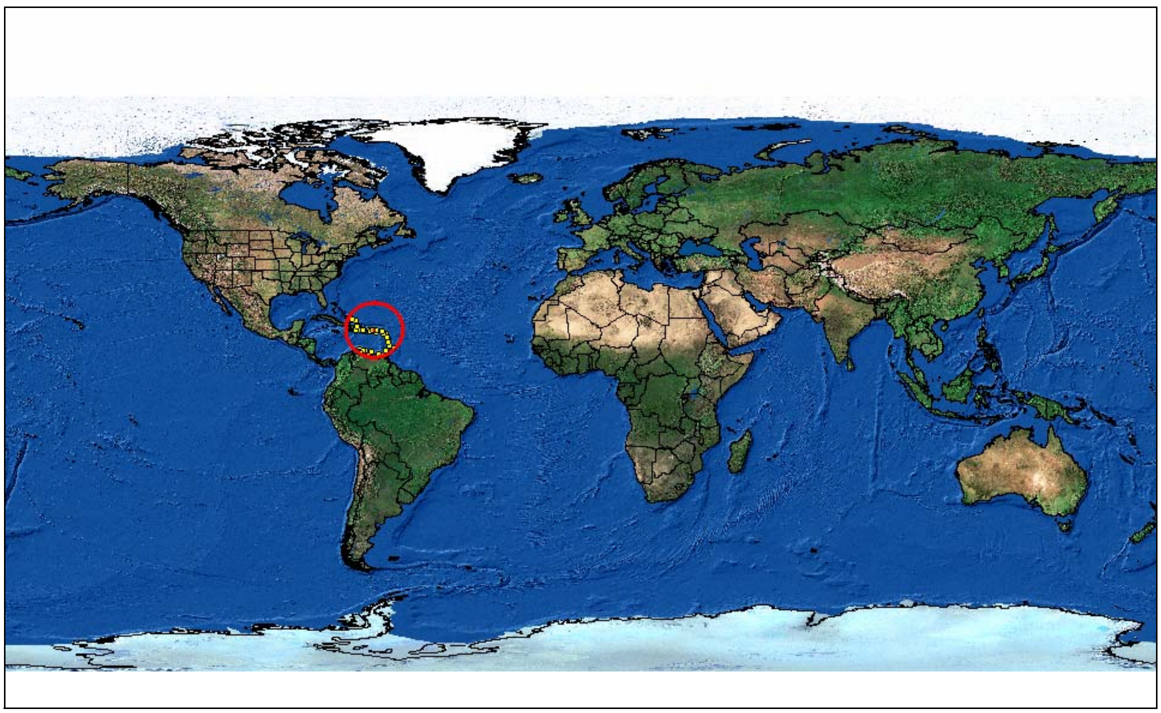


Figure 34. Roosevelt Roads, Puerto Rico.

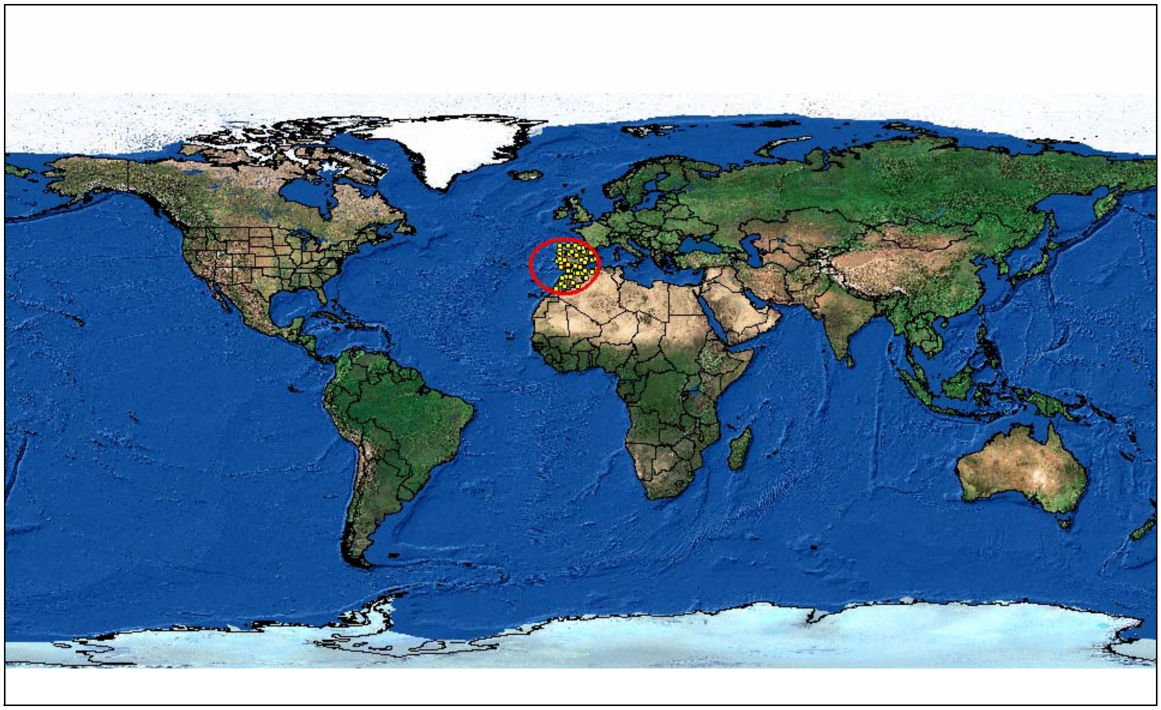


Figure 35. Rota NAS, Spain.

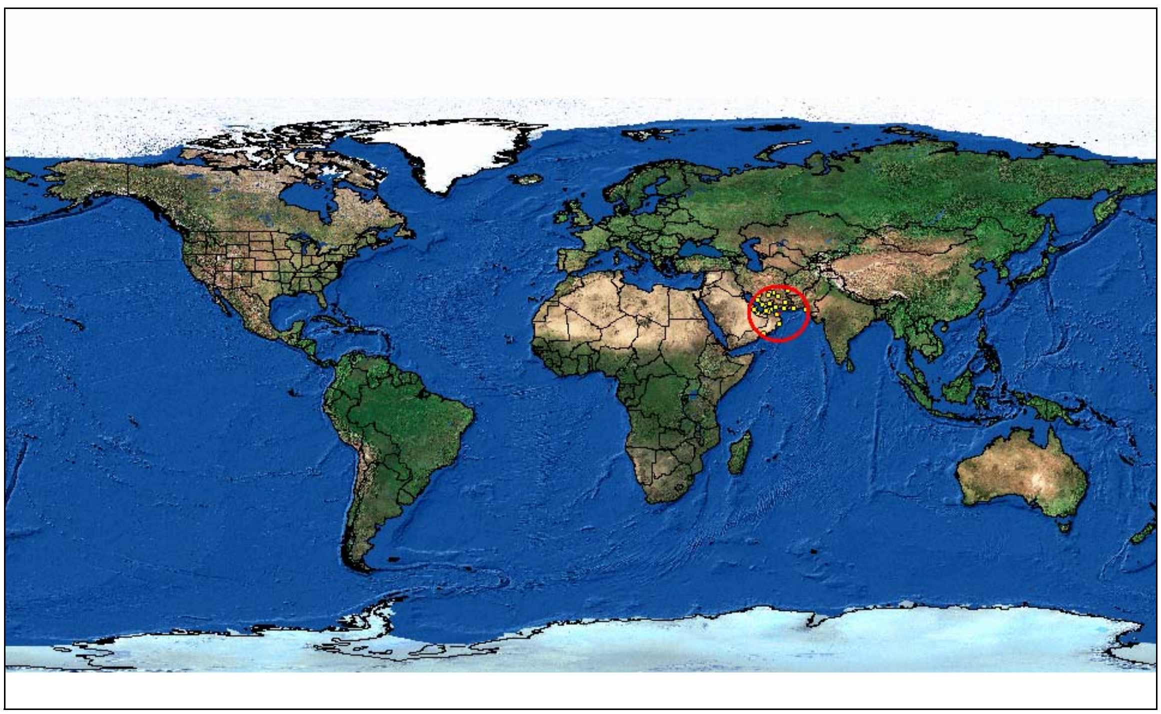


Figure 36. Seeb, Oman.

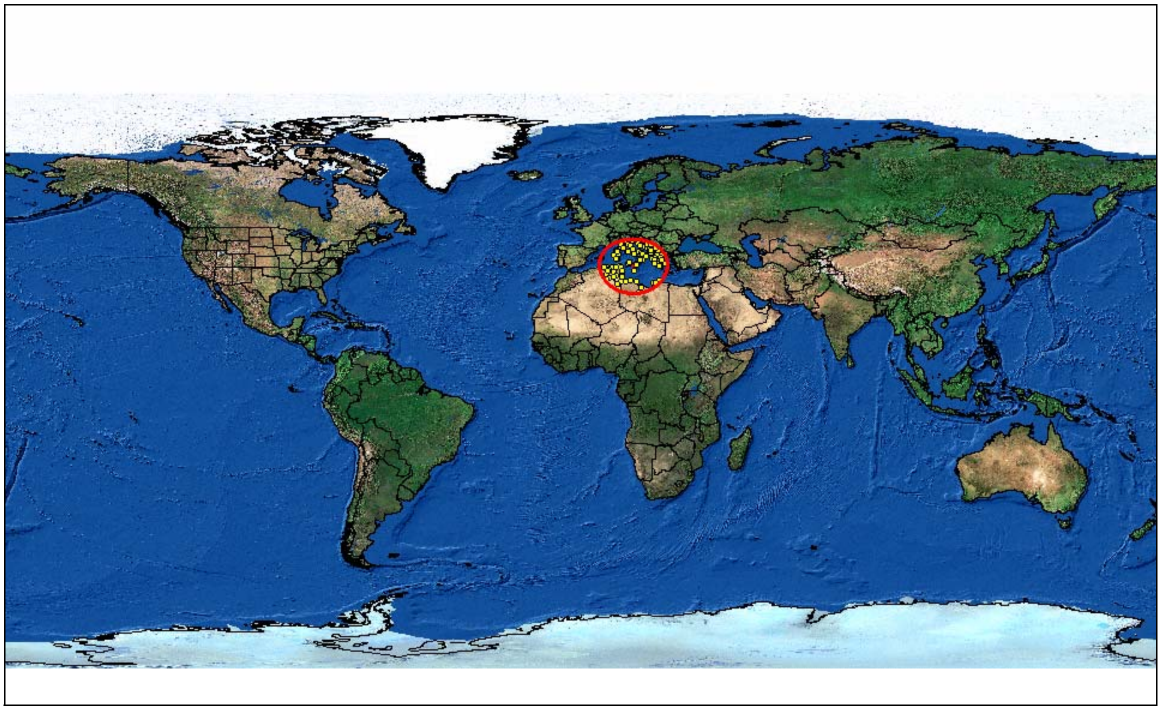


Figure 37. Sigonella AB, Italy.

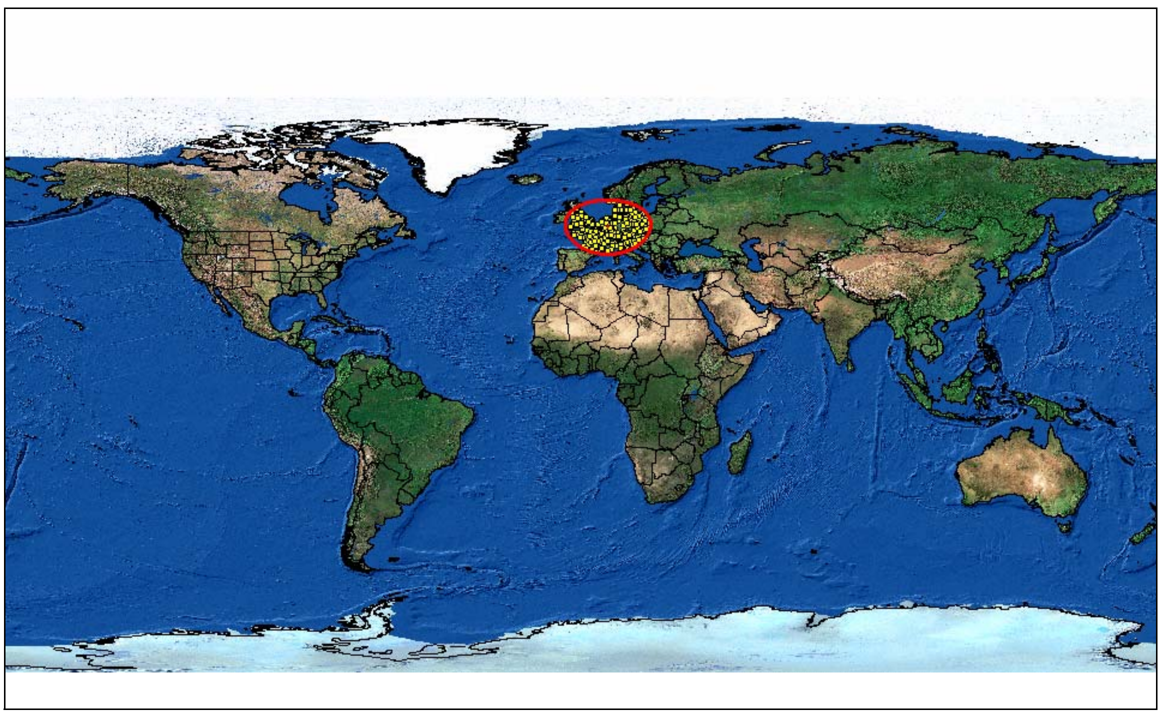


Figure 38. Spangdahlem AB, Germany.

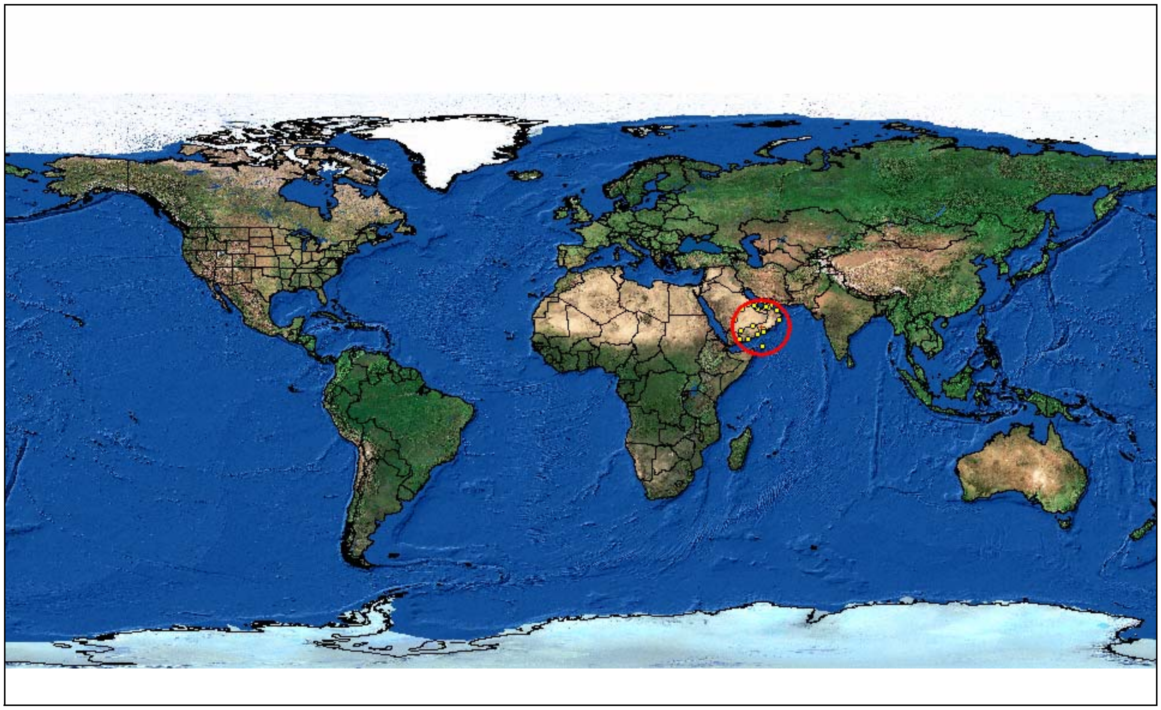


Figure 39. Thumrait, Oman.

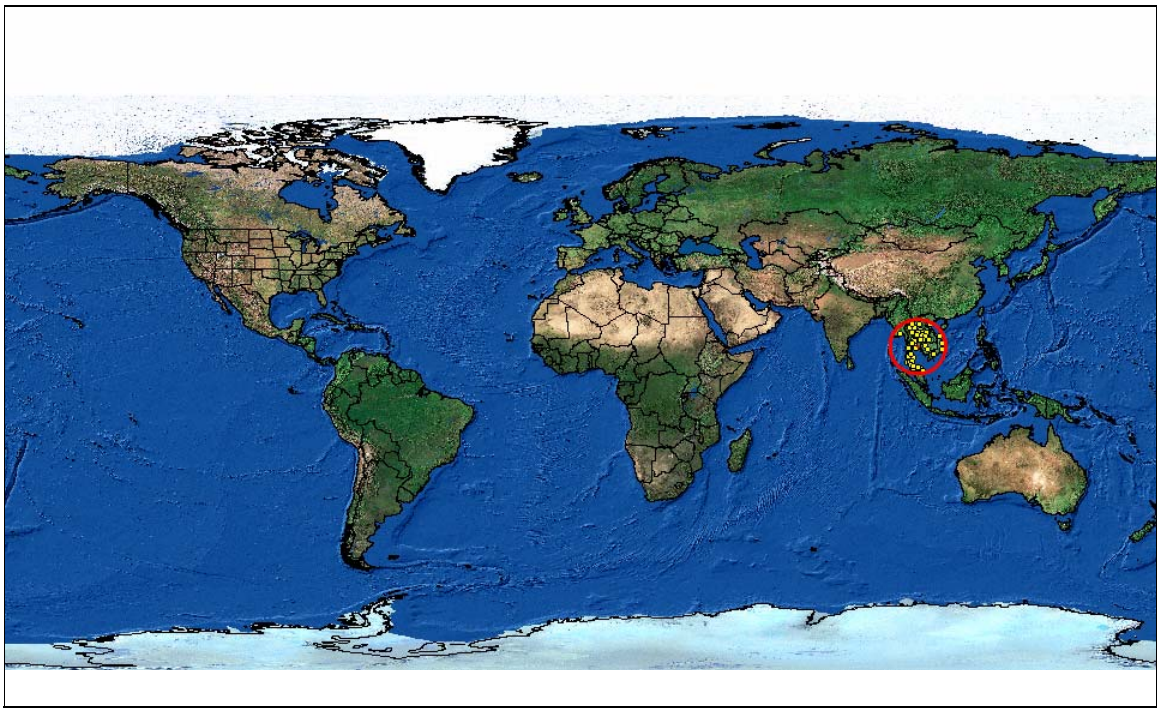


Figure 40. U-Taphao, Thailand.

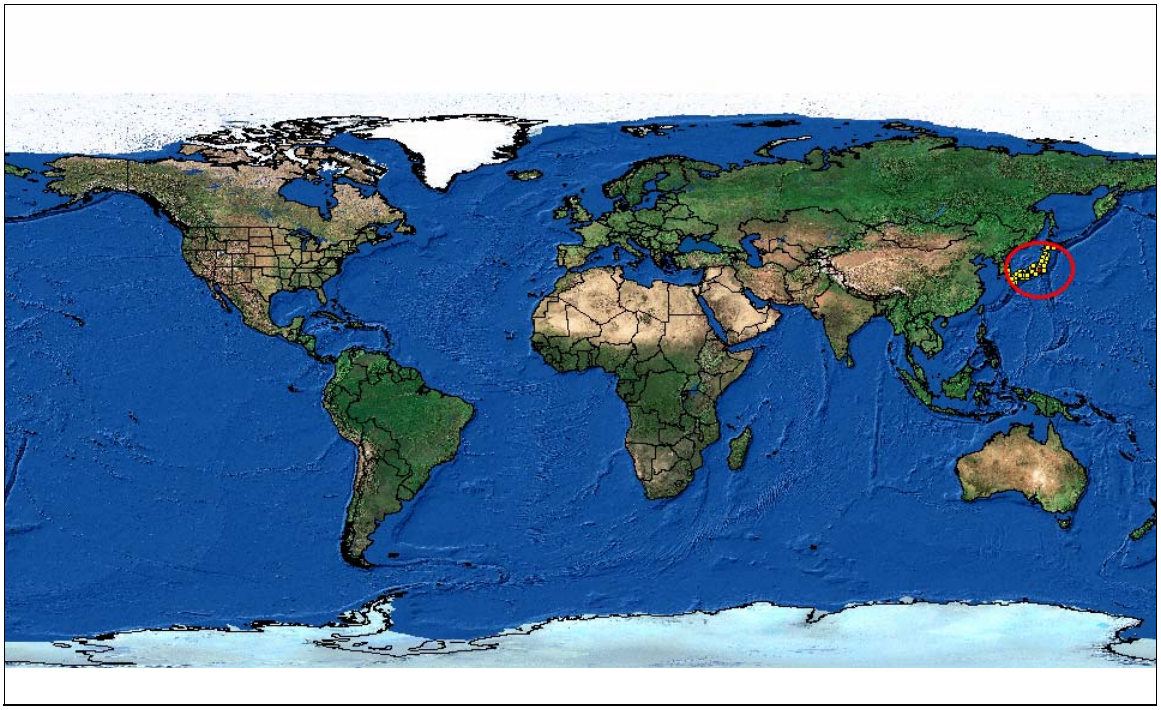


Figure 41. Yokota AB, Japan.

Appendix B. Single Dimensional Value Functions

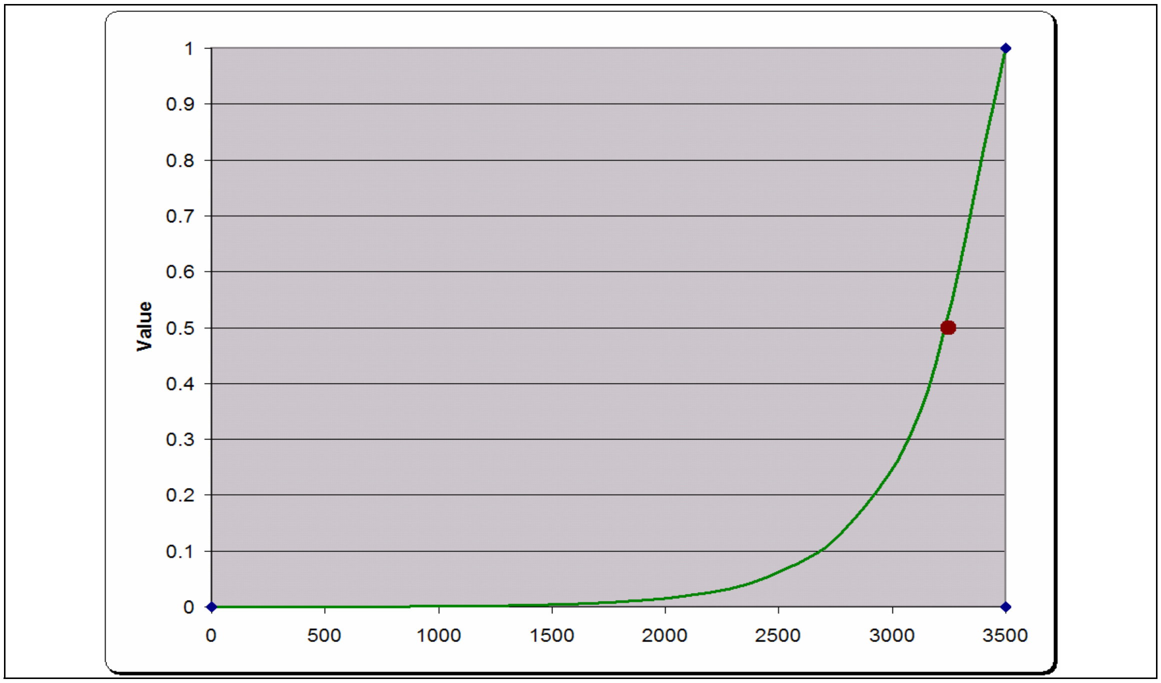


Figure 1. Critical Leg SDVF.

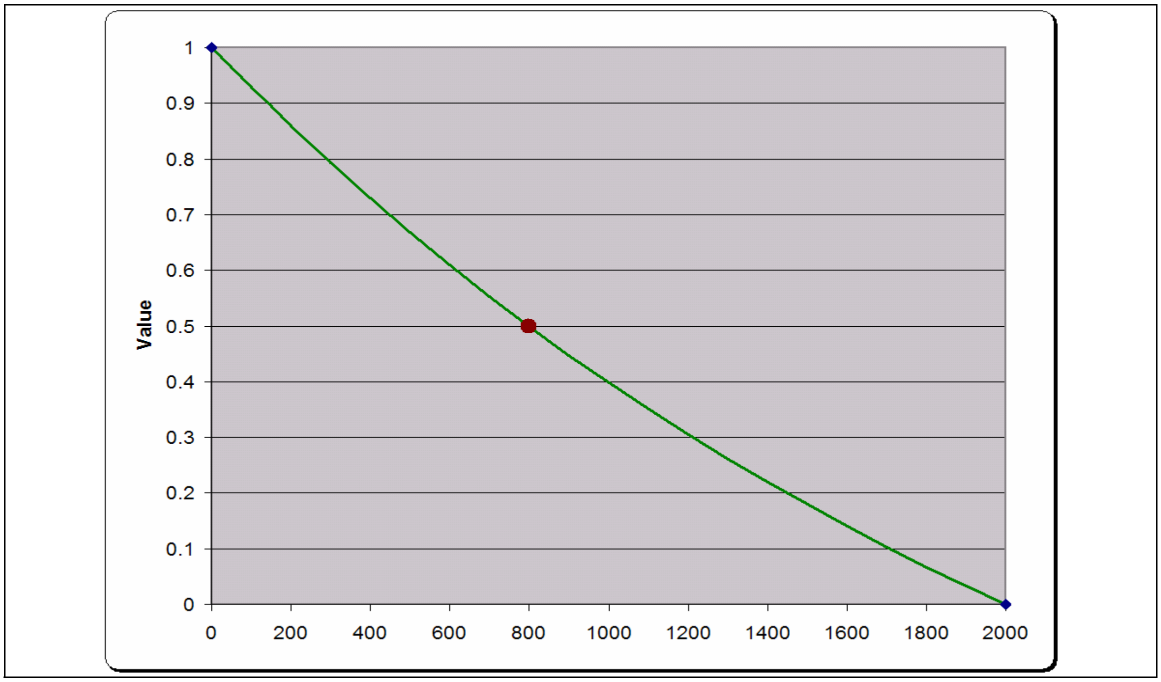


Figure 2. Flight Length Delta SDVF.

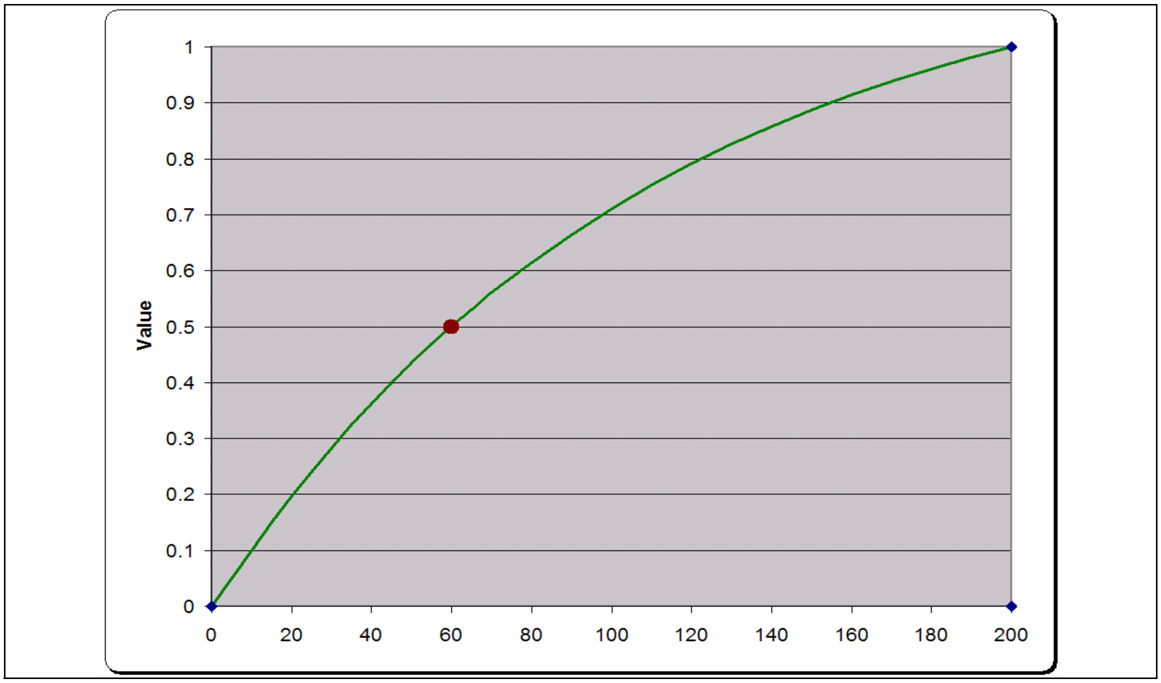


Figure 3. Alternate Airfields SDVF.

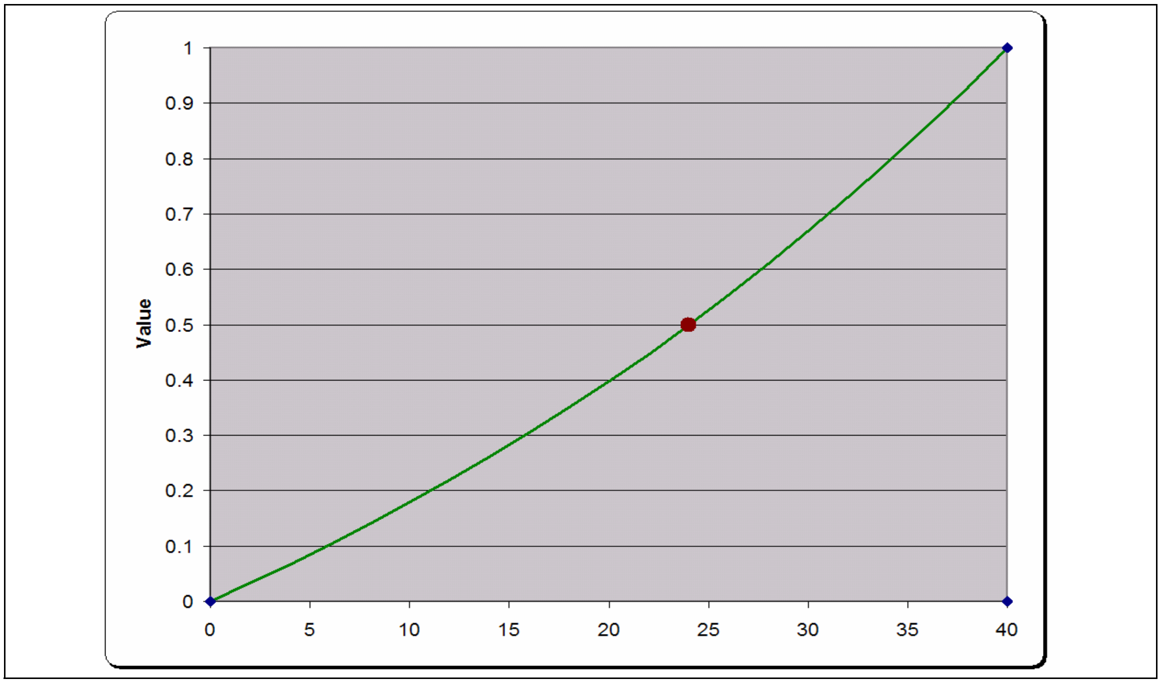


Figure 4. Parking MOG SDVF.

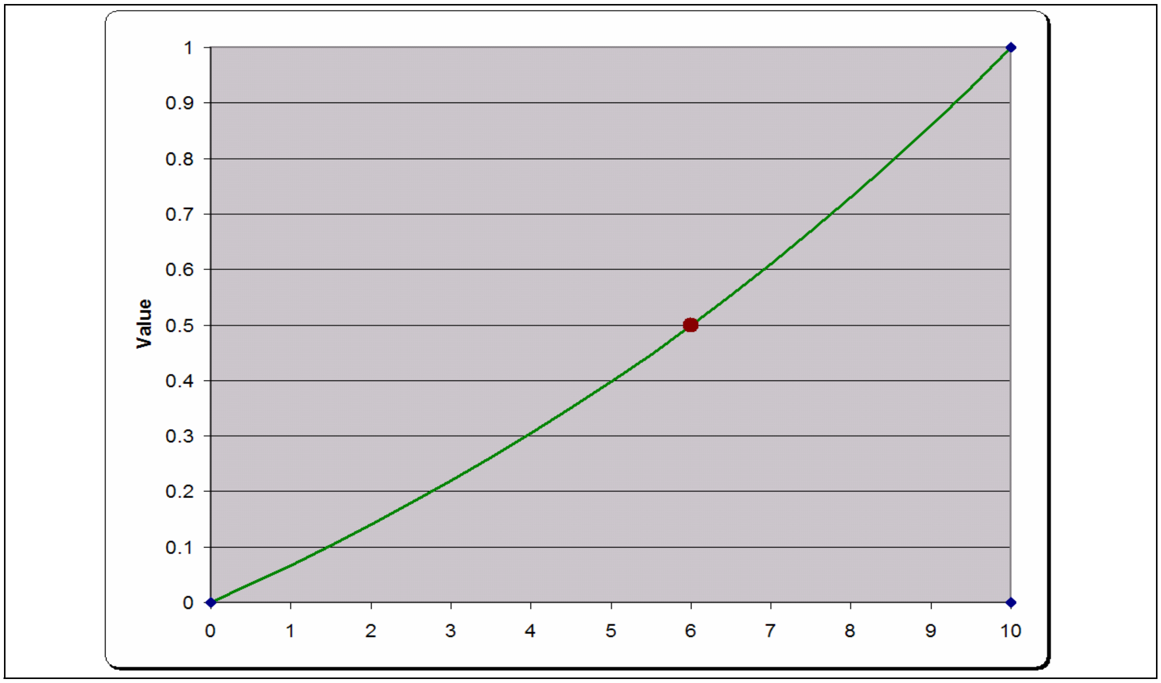


Figure 5. Working MOG SDVF.

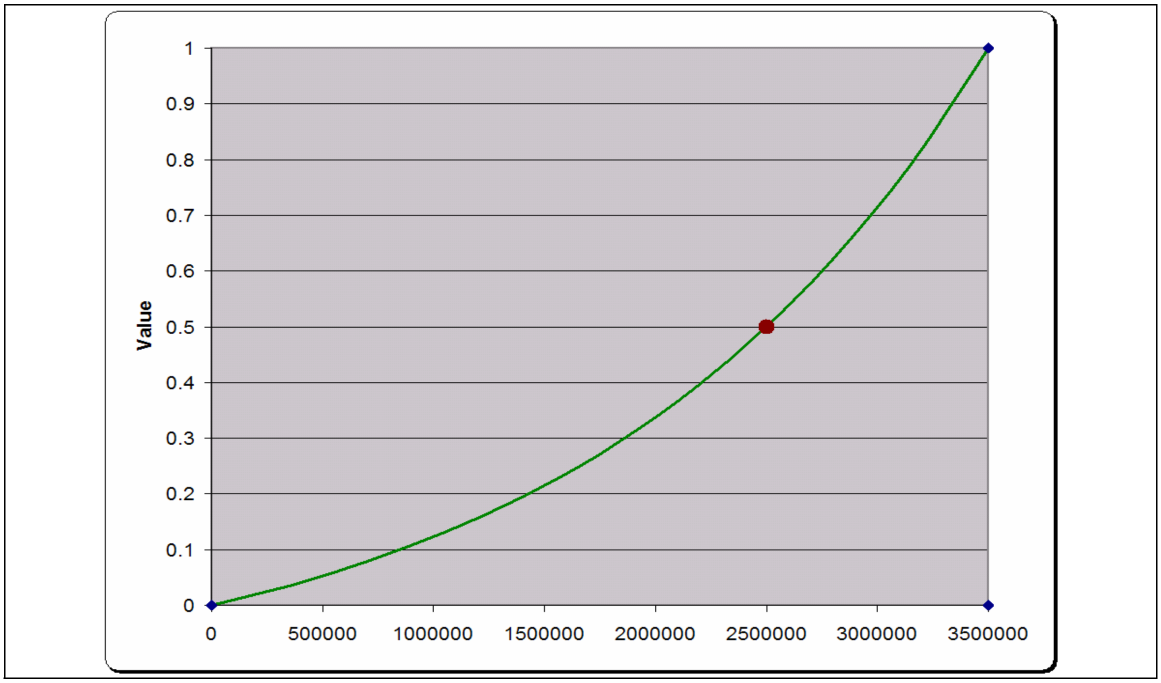


Figure 6. Fuel SDVF.

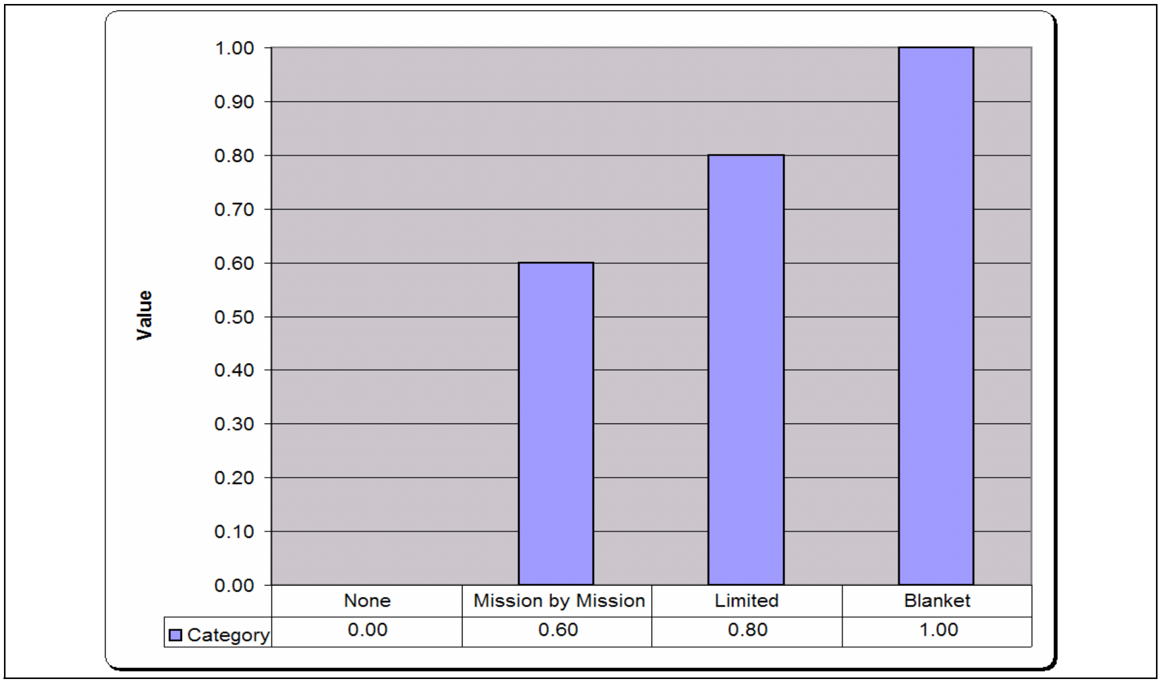


Figure 7. Diplomatic Clearance SDVF.

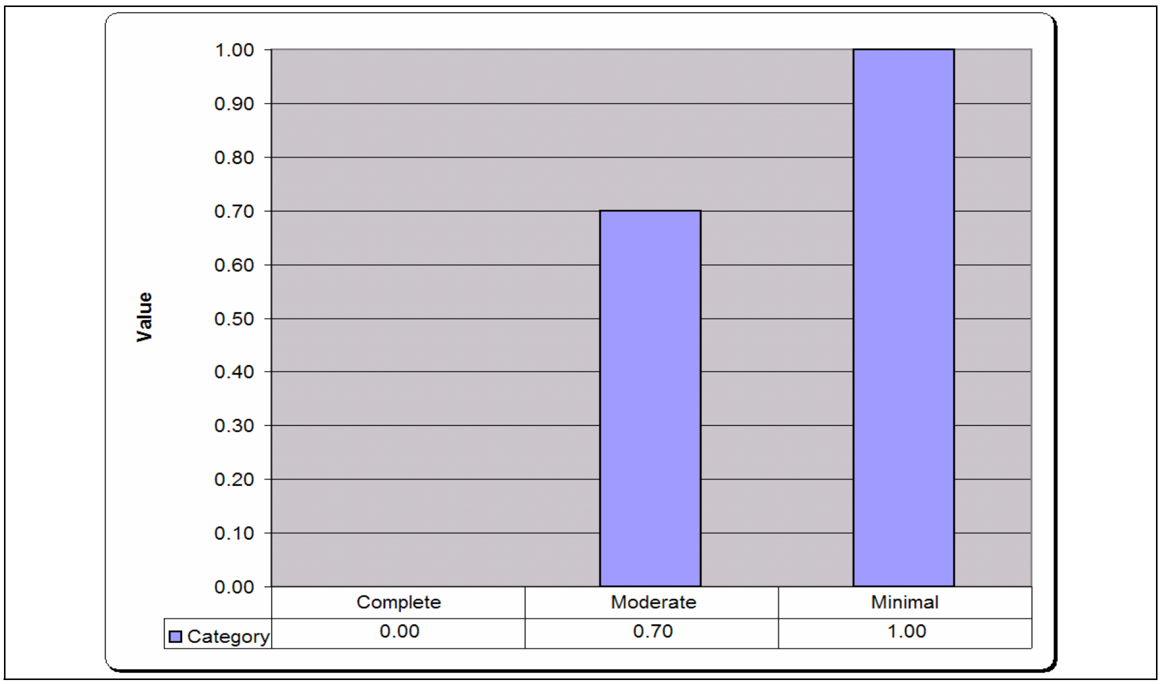


Figure 8. Force Protection SDVF.

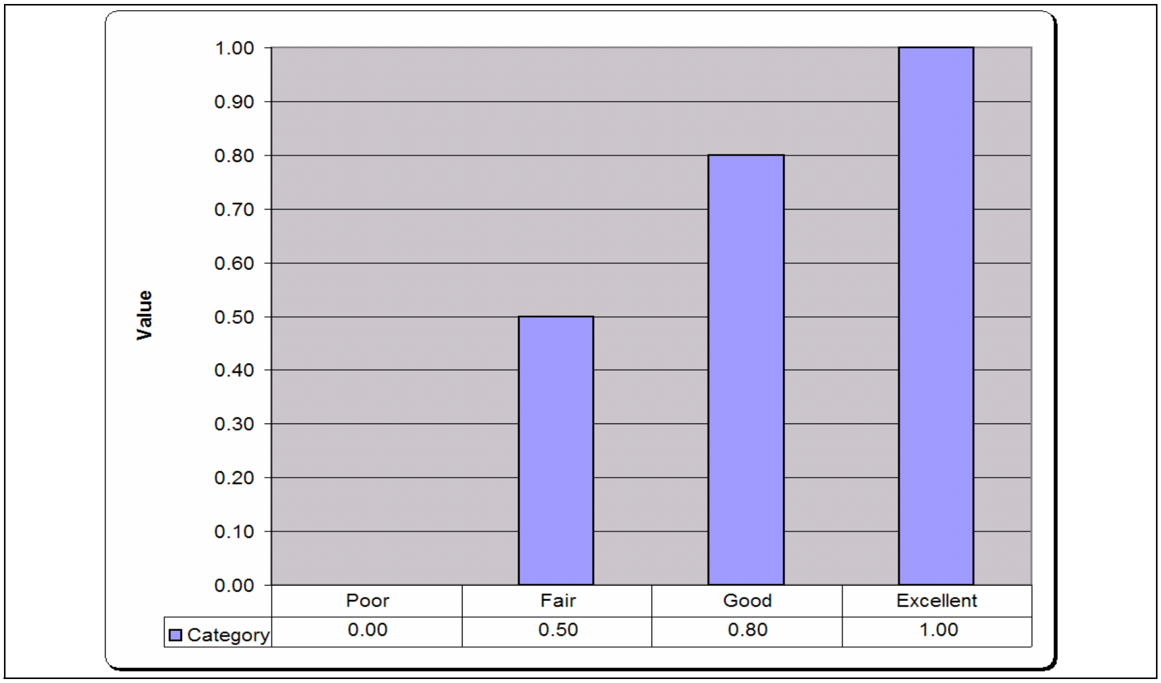


Figure 9. Military Cooperation SDVF.

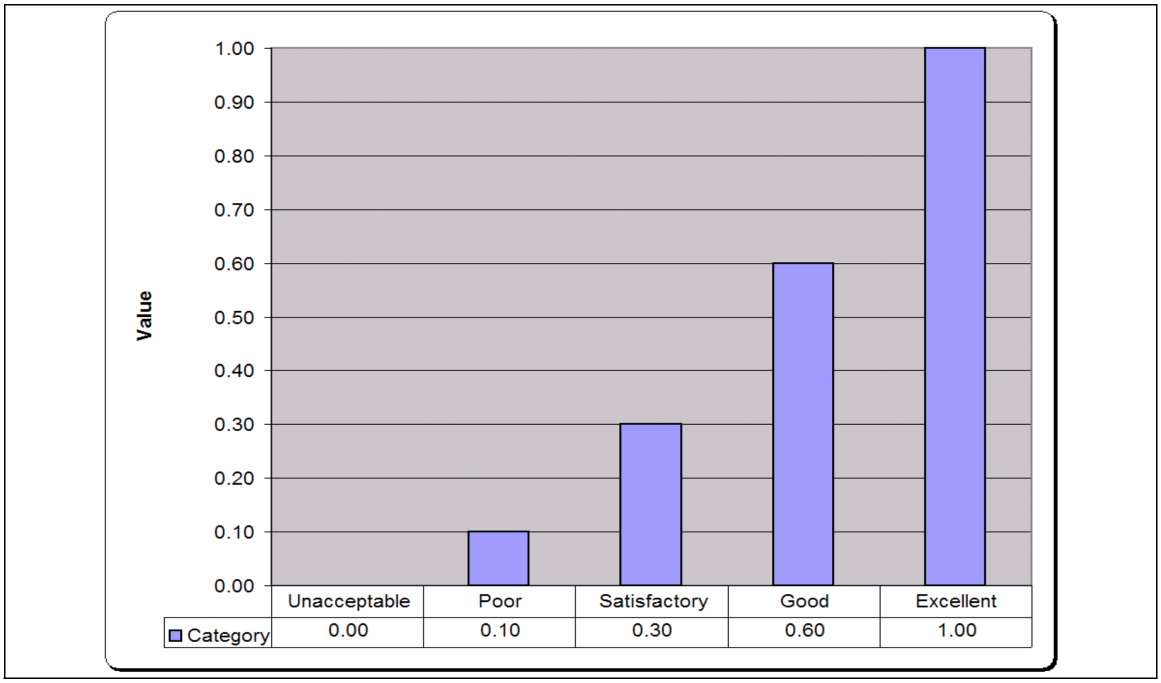


Figure 10. Department of State SDVF.

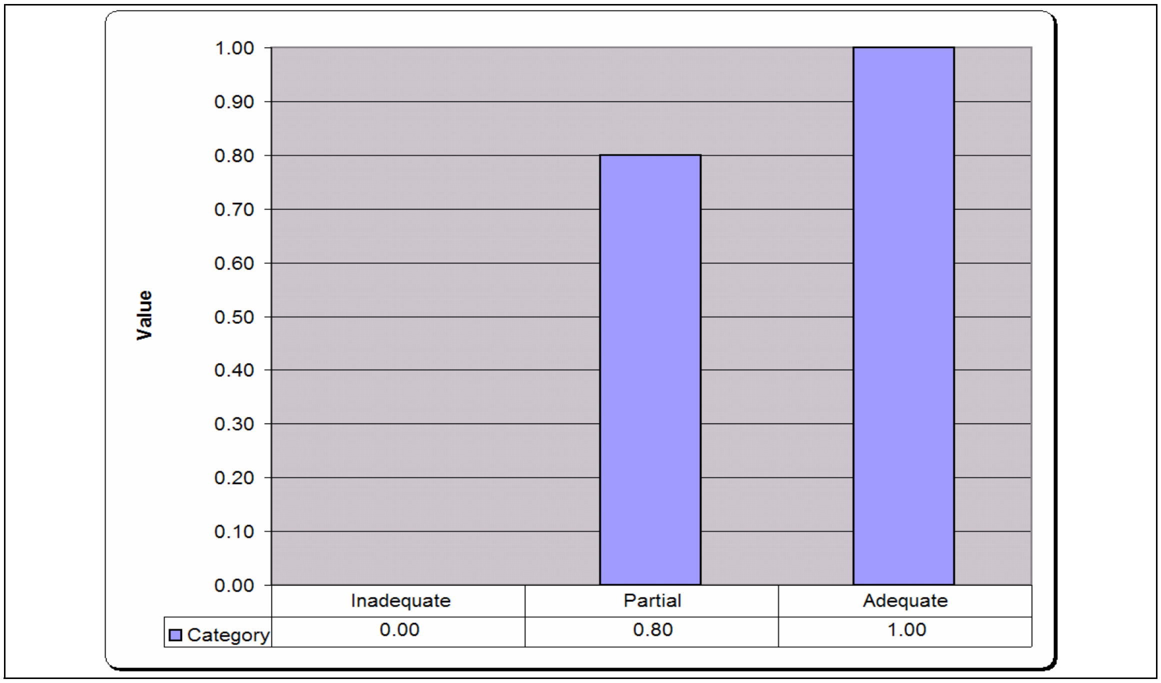


Figure 11. Lodging SDVF.

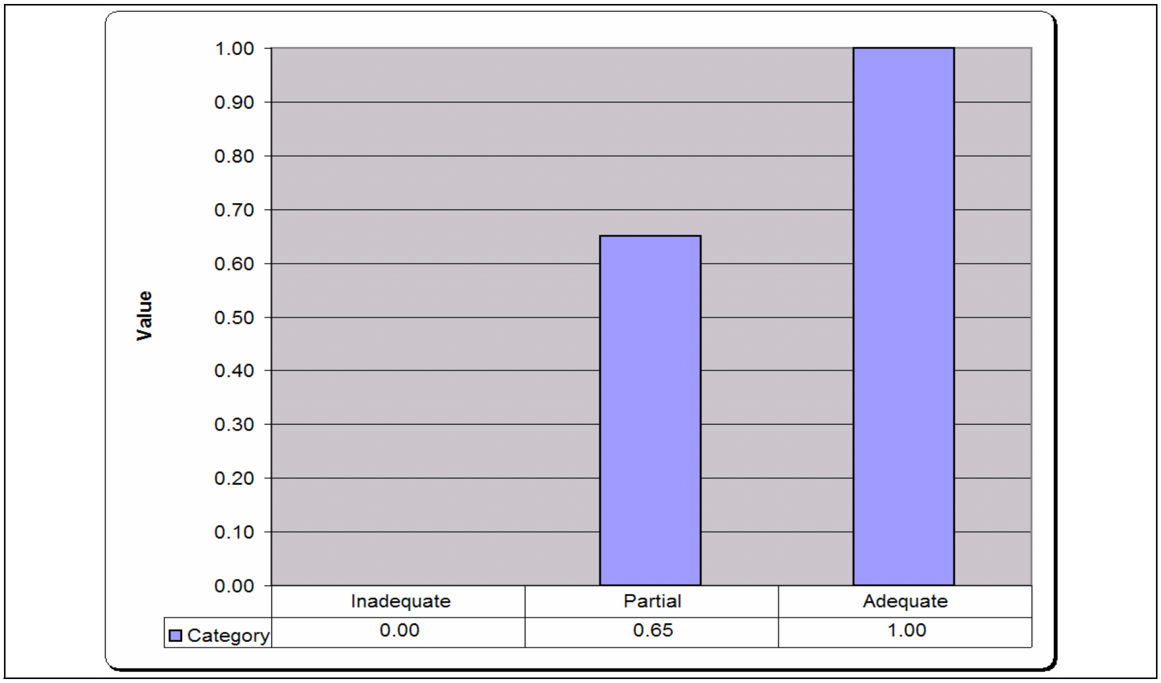


Figure 12. Dining SDVF.

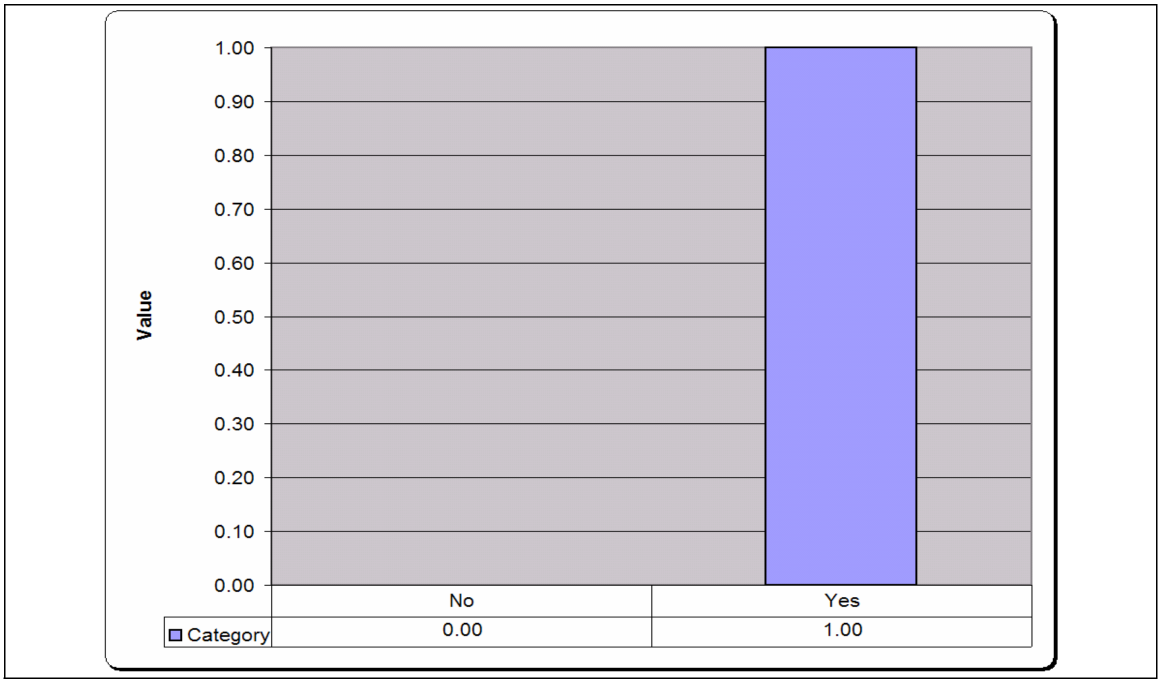


Figure 13. Medical SDVF.

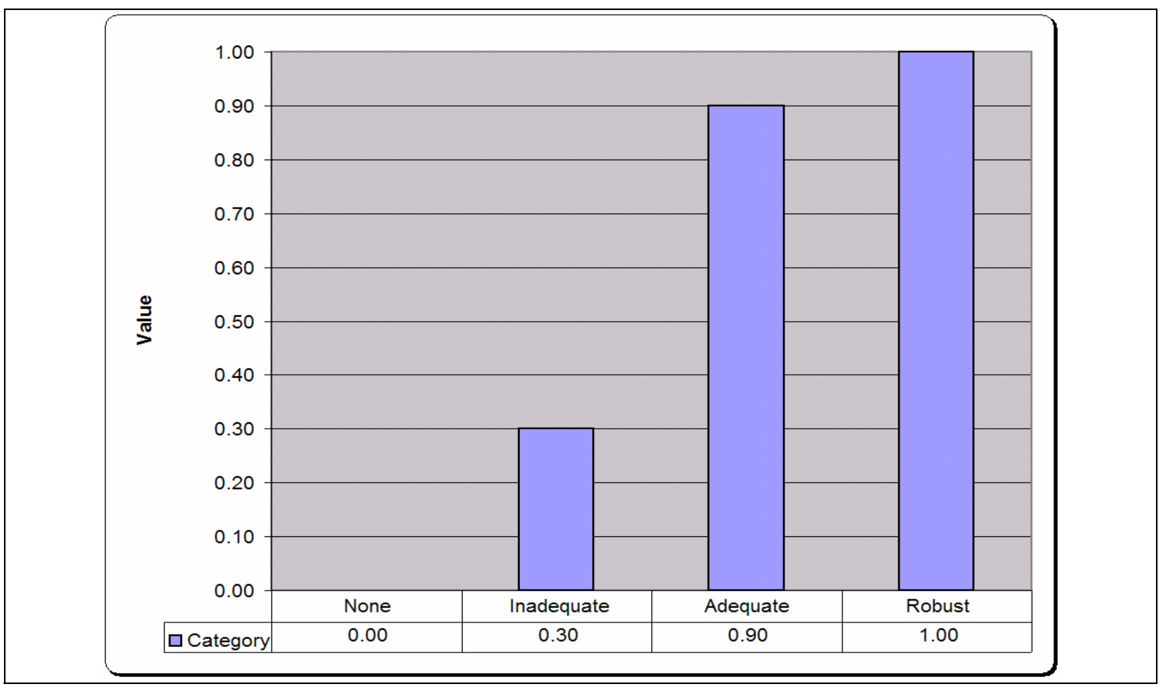


Figure 14. Communications SDVF.

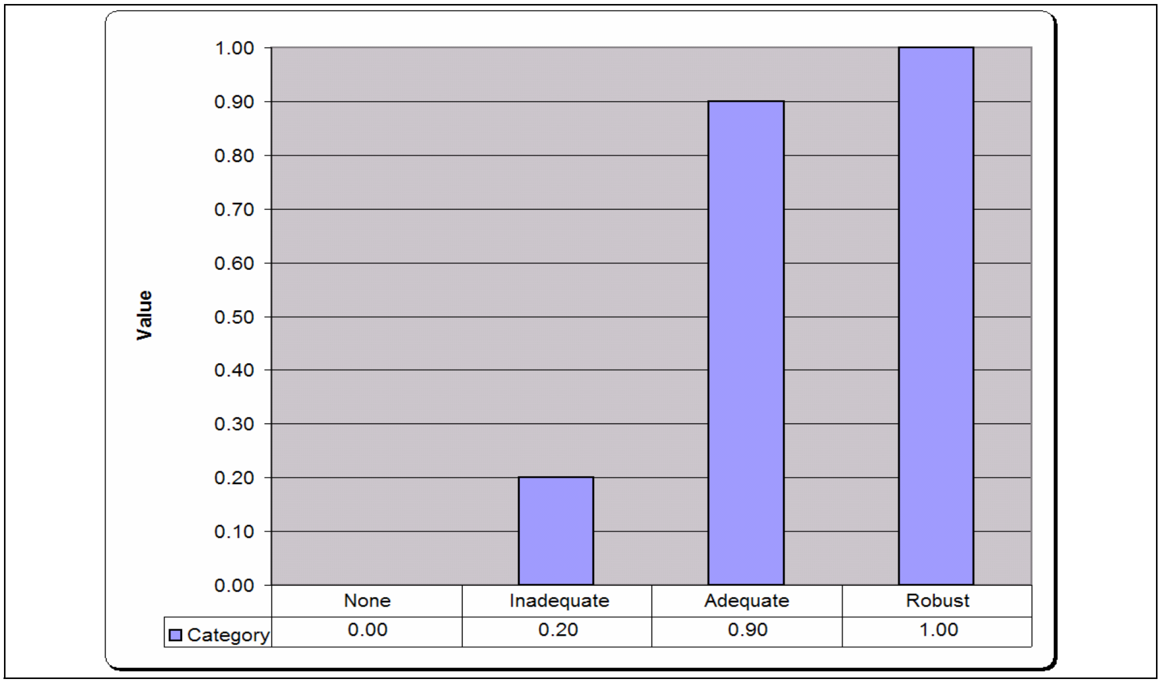


Figure 15. Power SDVF.

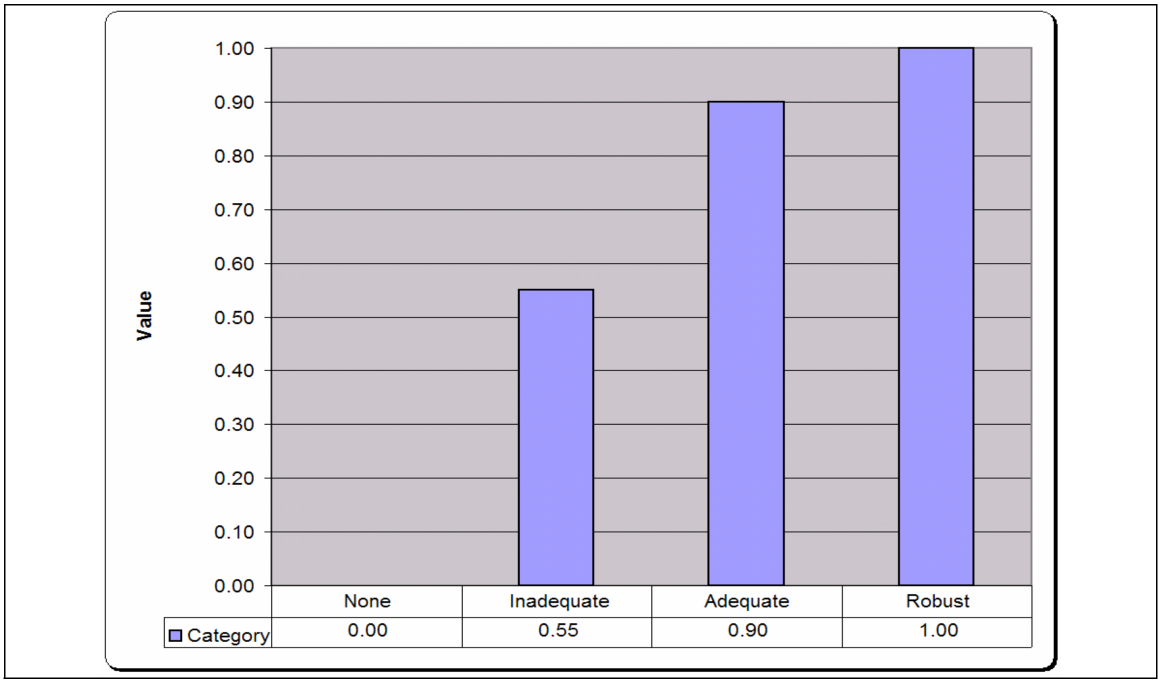


Figure 16. Potable Water SDVF.

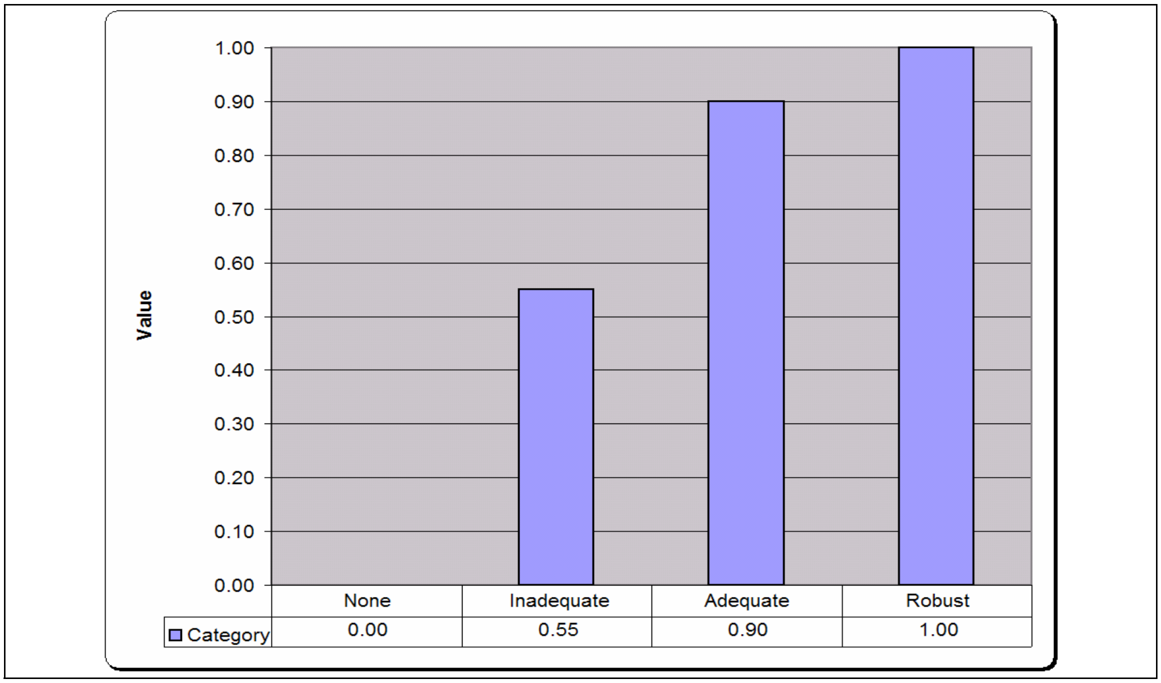


Figure 17. Sewer SDVF.

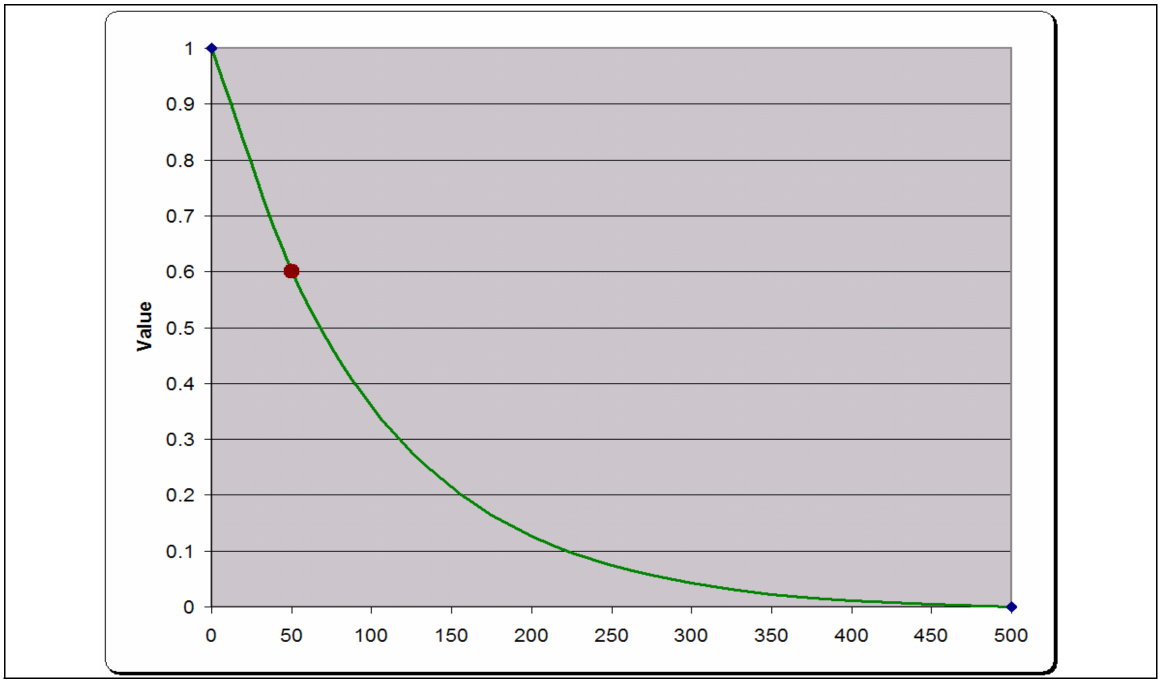


Figure 18. Seaports SDVF.

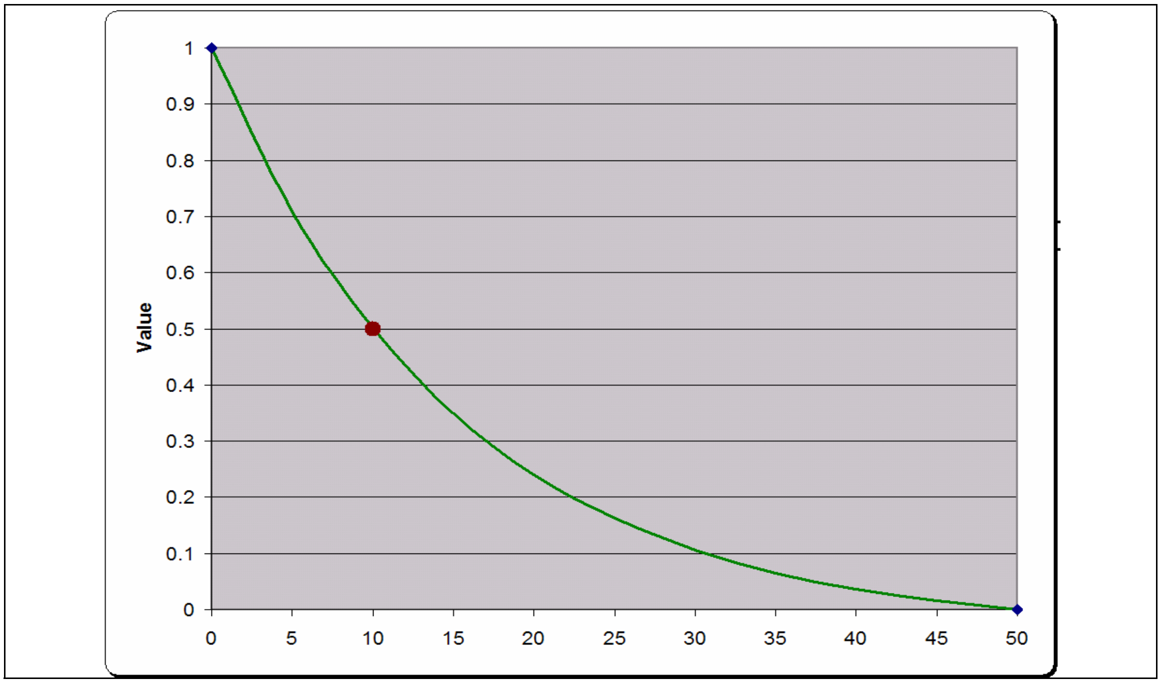


Figure 19. Railroads SDVF.

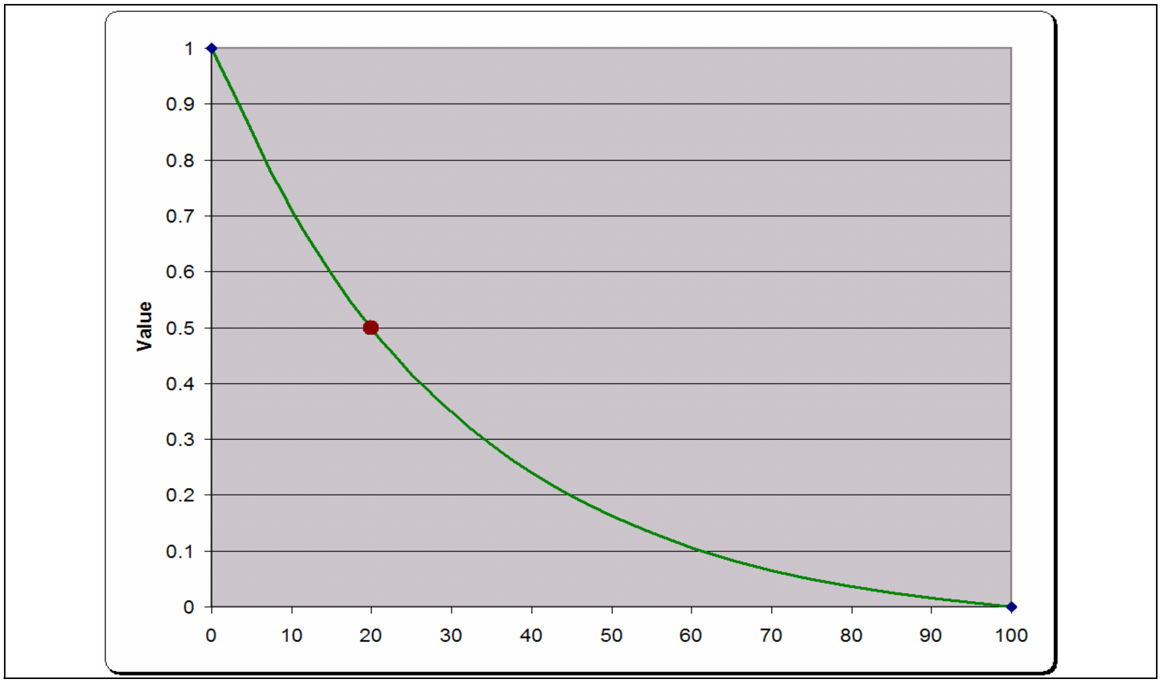


Figure 20. Road System SDVF.

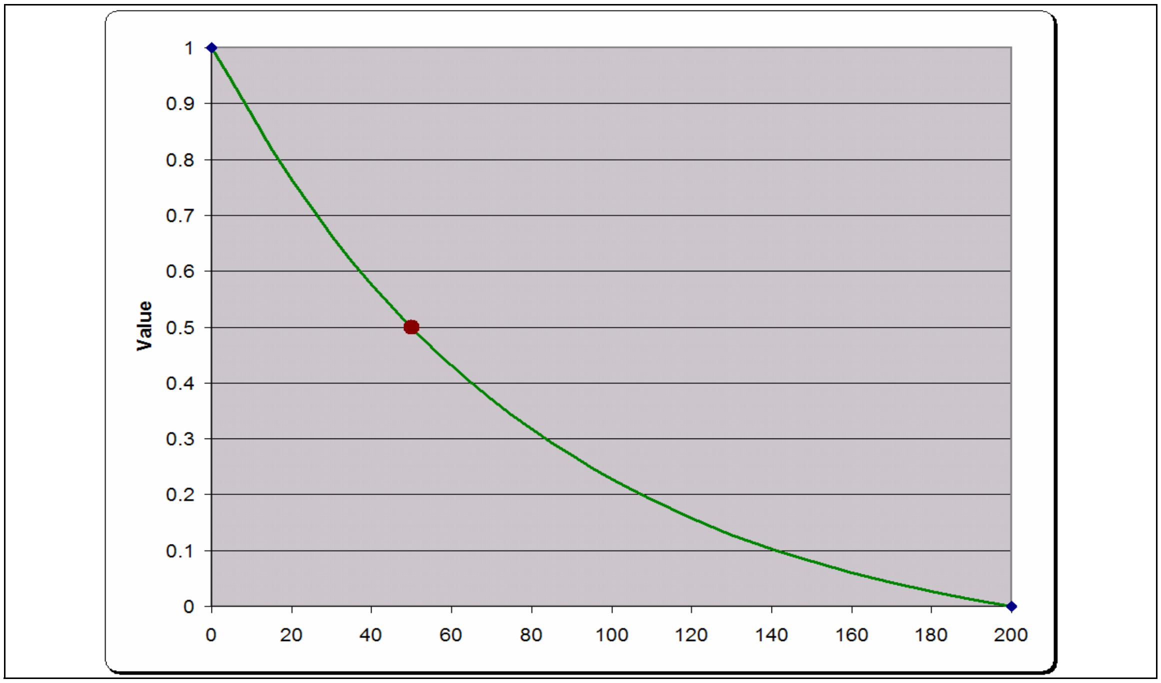


Figure 21. Commercial Airports SDVF.

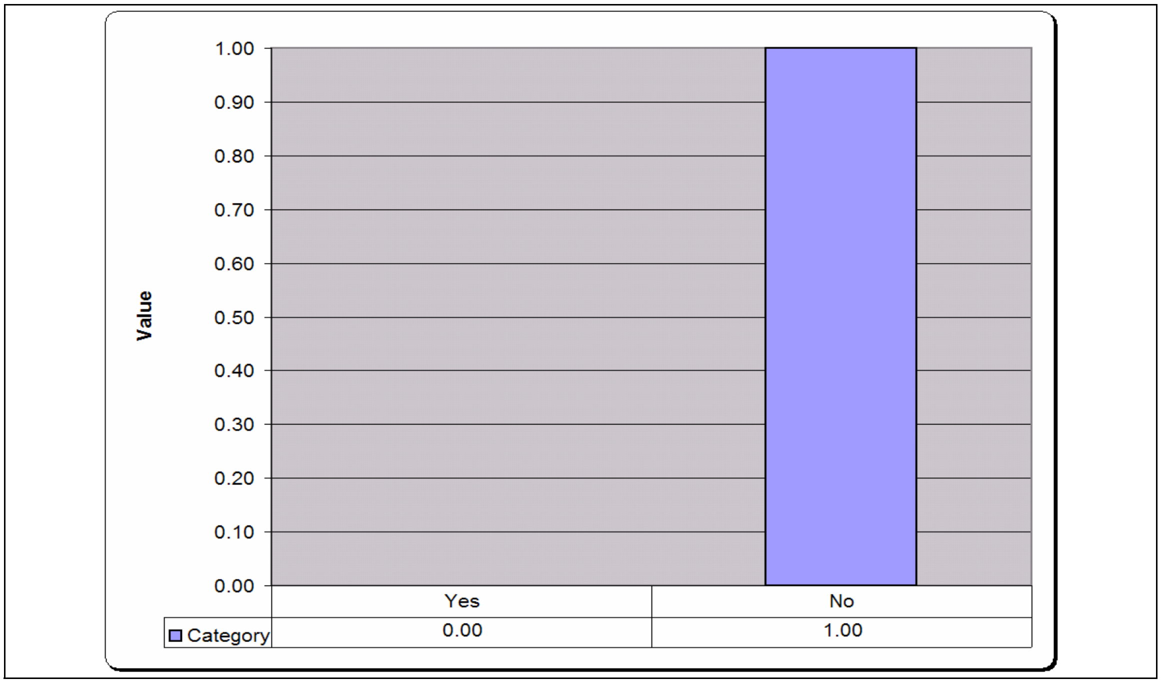


Figure 22. Climate SDVF.

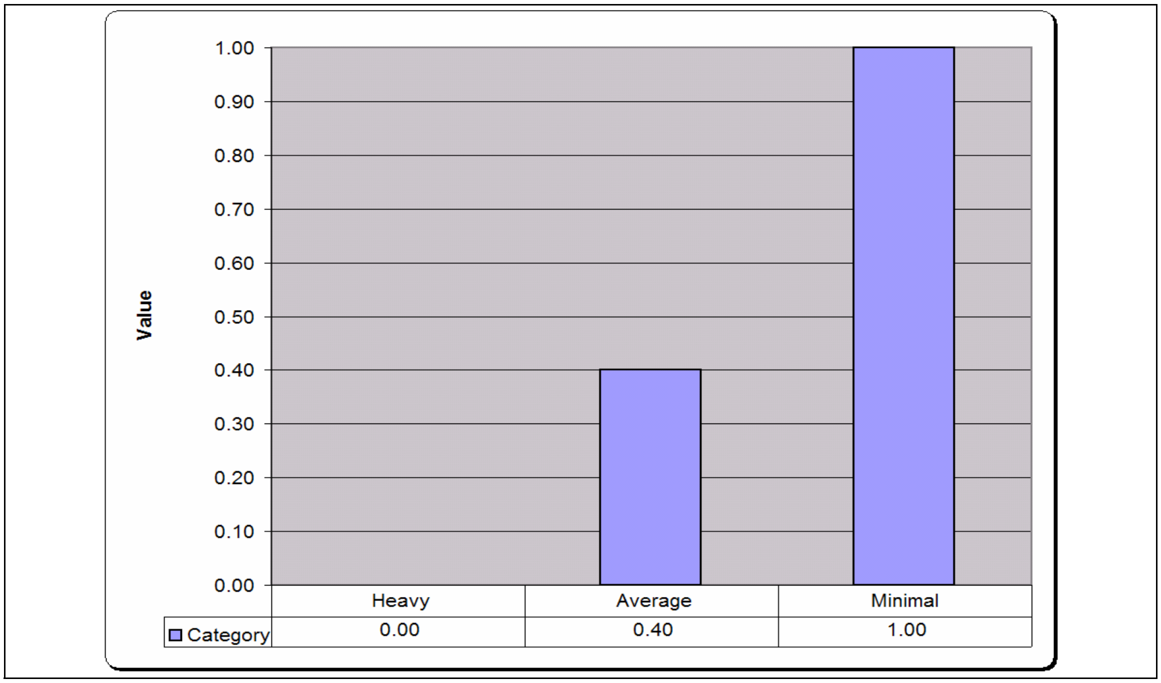


Figure 23. Weather SDVF.

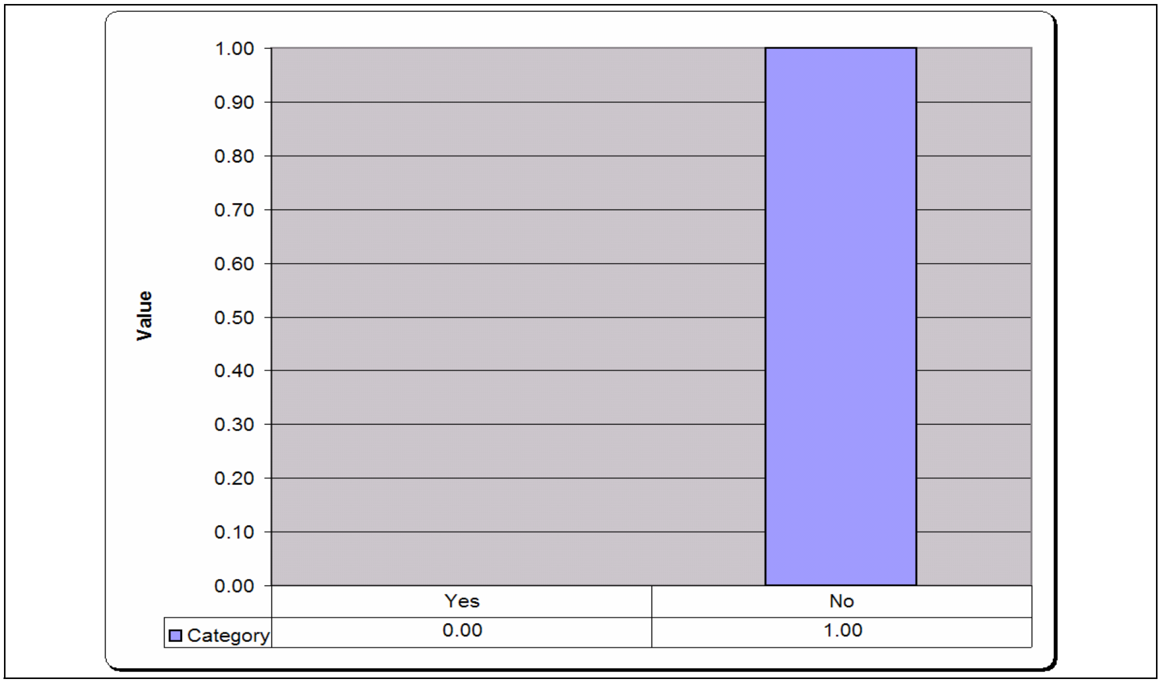


Figure 24. Altitude SDVF.

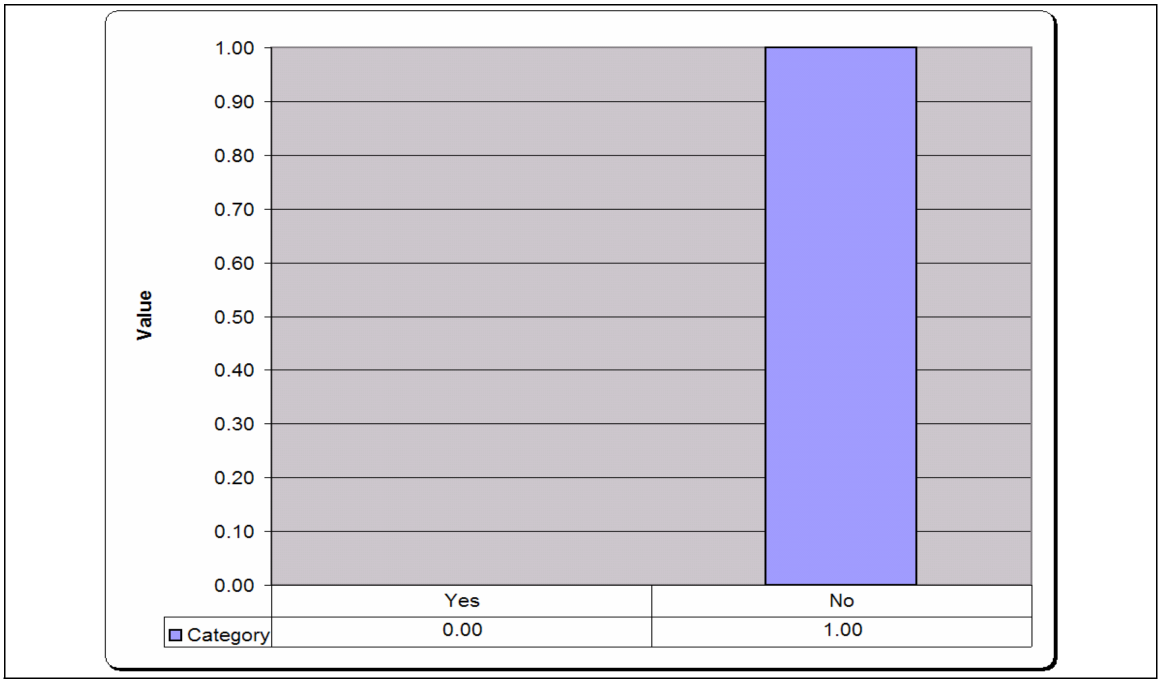


Figure 25. Mountainous SDVF.

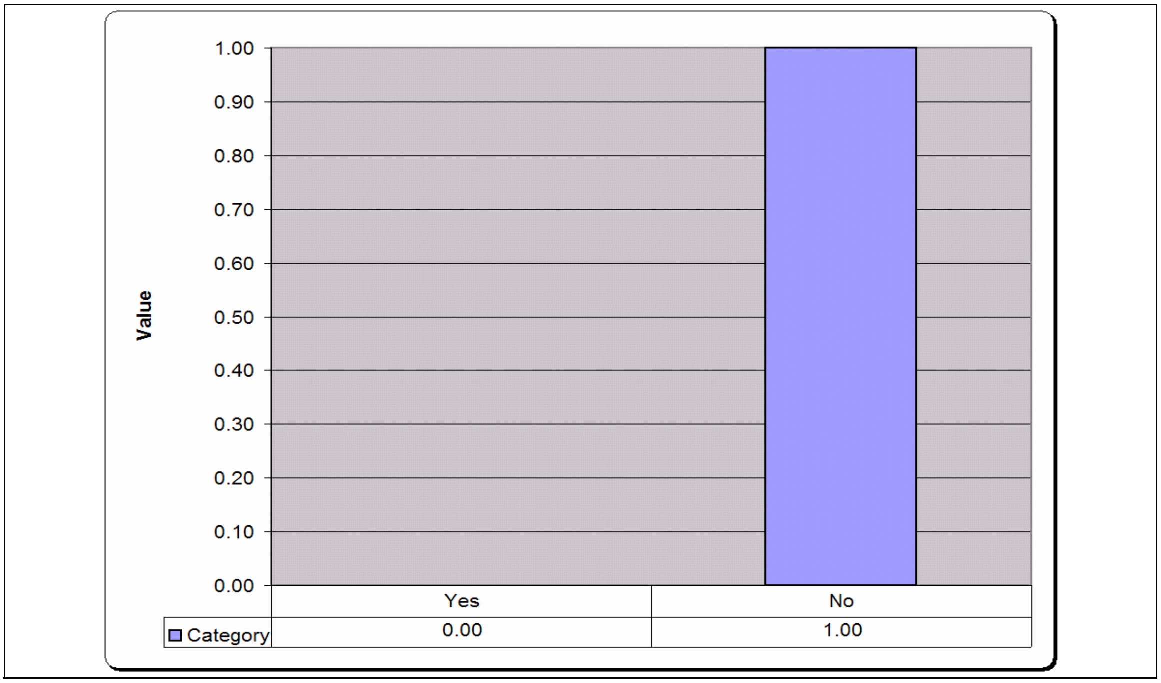


Figure 26. Terrain SDVF.

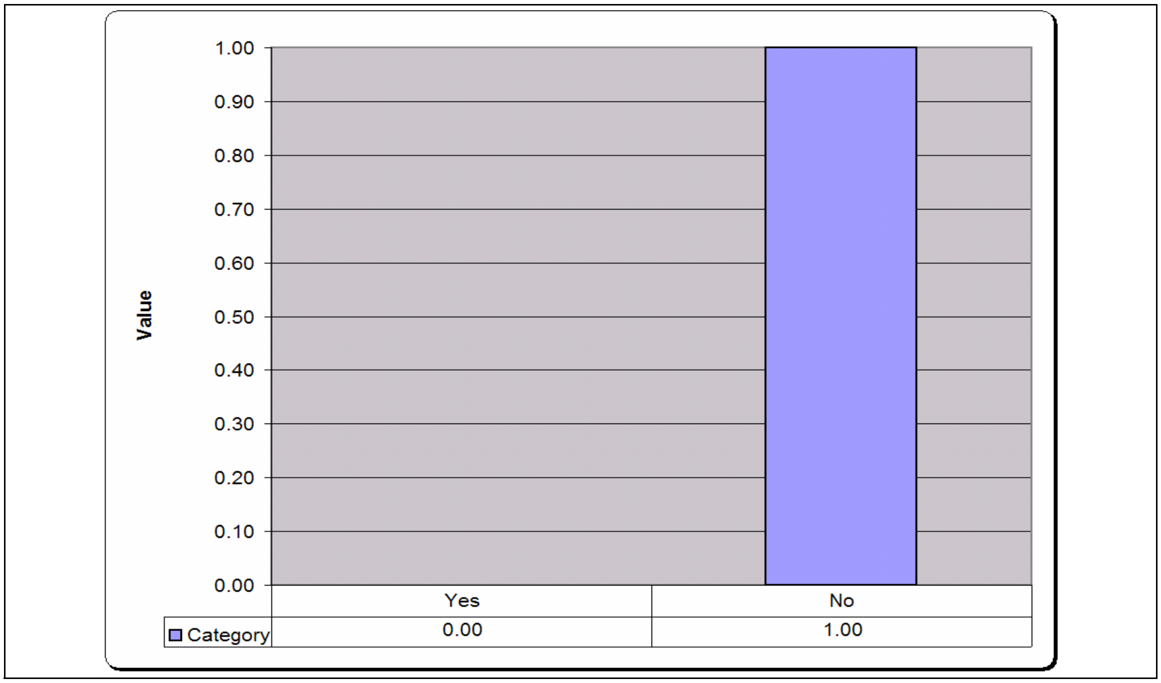


Figure 27. Urban Areas SDVF.

Appendix C. Local and Global Hierarchy Weights

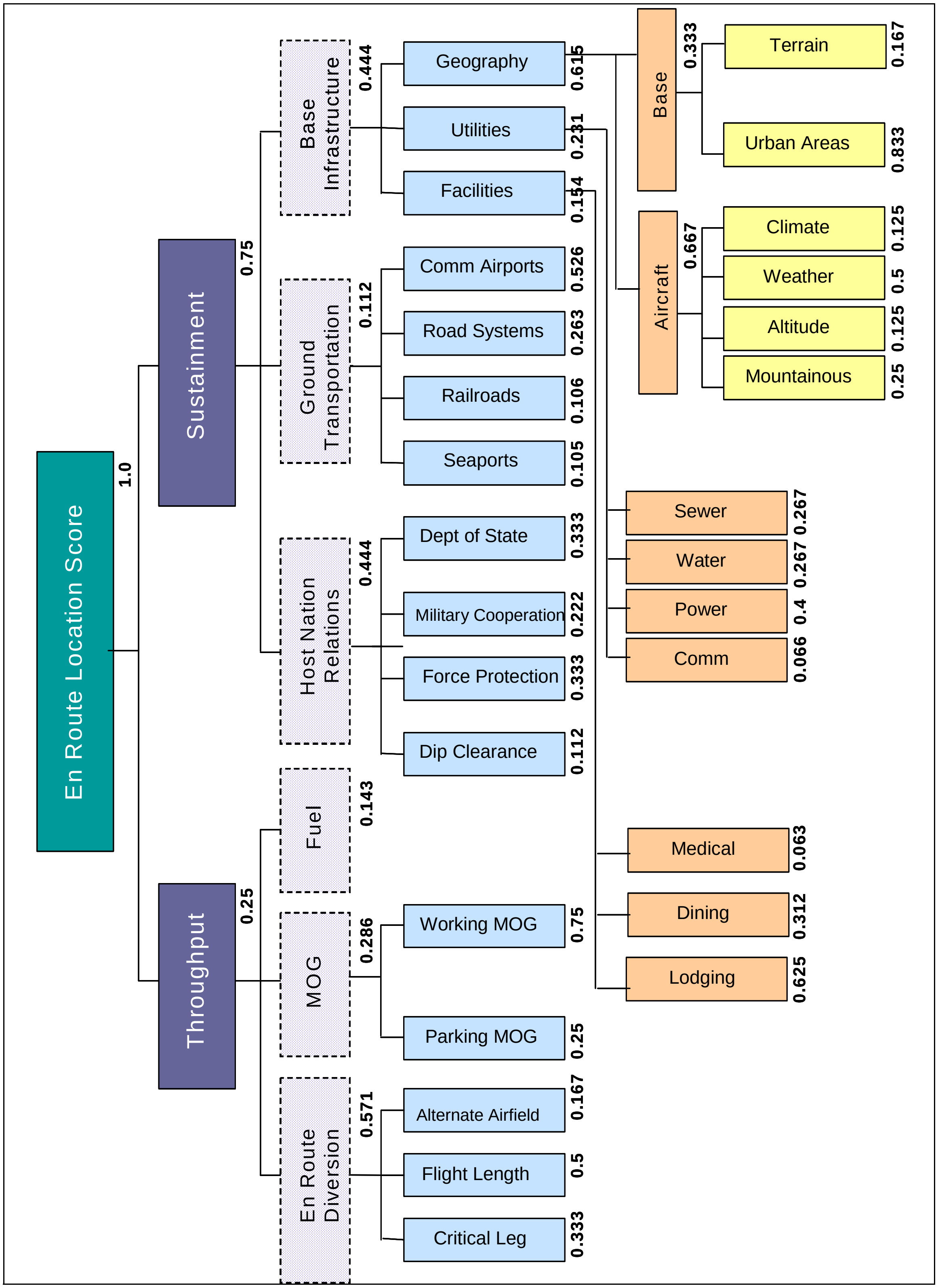


Figure 1. Local Hierarchy Weights.

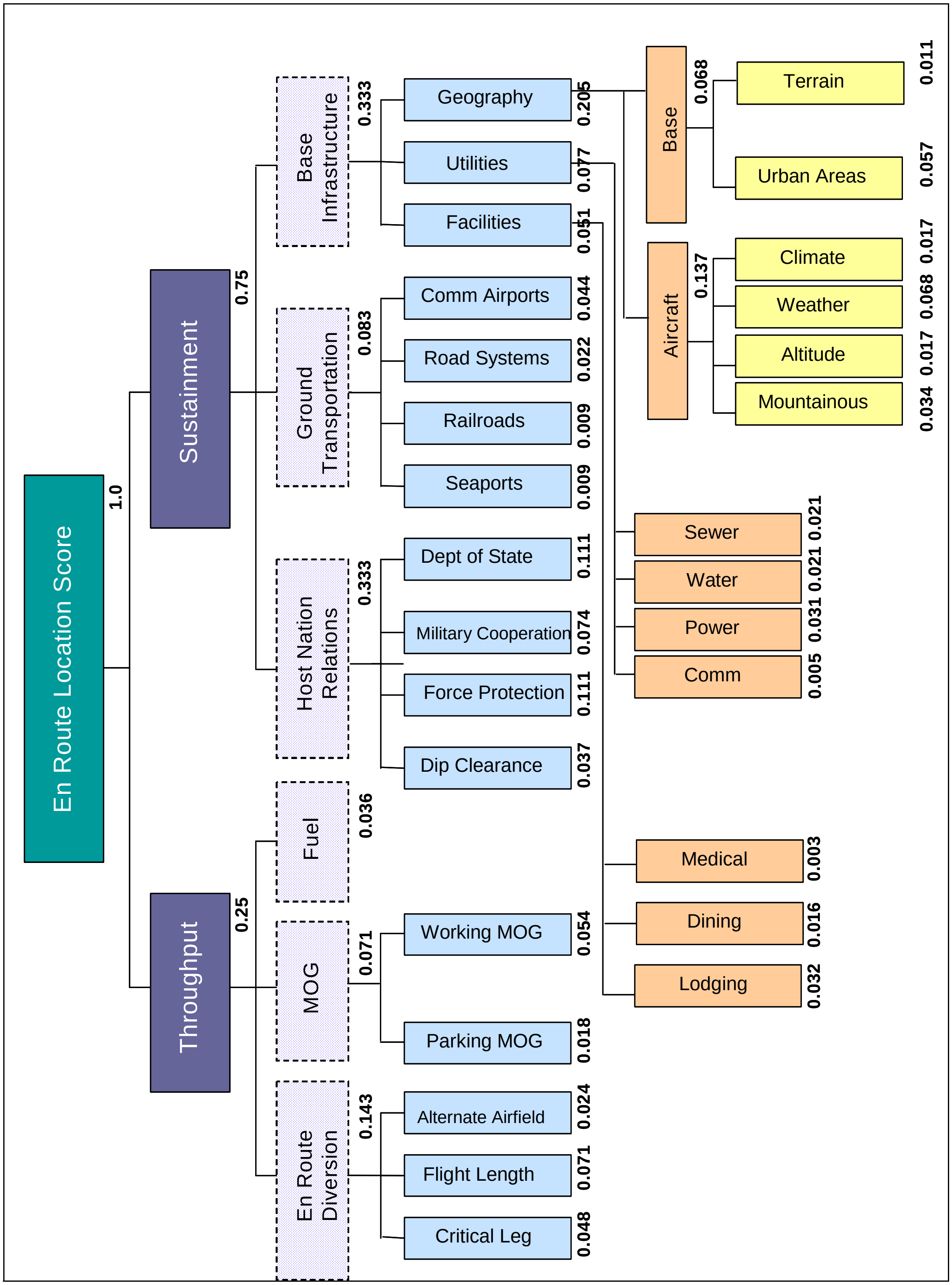


Figure 2. Global Hierarchy Weights.

Appendix D. Results for All Origin/Destination Pairs

Table 1. Results for Original Model and Experiments 1-3-Baghdad International, Iraq.

Original Preference Structure		Experiment 1		Experiment 2		Experiment 3	
		Adjusted Preference Strucutre		Weighted CONUS Origins		Combinations of Experiments 1 and 2	
		Throughput (.7), Sustainment (.3)					
en routes	scores	en routes	scores	en routes	scores	en routes	scores
RAF Fairford, England	0.427932	RAF Fairford, England	0.380696	RAF Fairford, England	0.436725	RAF Fairford, England	0.405316
Ramstein AB, Germany	0.325962	Ramstein AB, Germany	0.234313	Ramstein AB, Germany	0.278921	Lajes, Portugal	0.231477
Rota NAS, Spain	0.316034	Rota NAS, Spain	0.216263	Rota NAS, Spain	0.268013	Ramstein AB, Germany	0.21114
Lajes, Portugal	0.312608	Lajes, Portugal	0.204374	Lajes, Portugal	0.341457	Rota NAS, Spain	0.188786
Moron AB, Spain	0.297667	Moron AB, Spain	0.203046	Moron AB, Spain	0.25273	Moron AB, Spain	0.178091
Mildenhall AB, United Kingdom	0.280752	Spangdahlem AB, Germany	0.201941	Mildenhall AB, United Kingdom	0.239944	Mildenhall AB, United Kingdom	0.1719
Spangdahlem AB, Germany	0.264606	Mildenhall AB, United Kingdom	0.190933	Spangdahlem AB, Germany	0.158764	Spangdahlem AB, Germany	0.121164
Constanta, Romania	0.240867	Constanta, Romania	0.173128	Constanta, Romania	0.14452	Constanta, Romania	0.103877
Sigonella AB, Italy	0.231779	Incirlik AB, Turkey	0.173089	Sigonella AB, Italy	0.139067	Incirlik AB, Turkey	0.103853
Kotoka, Ghana	0.214243	Burgas, Bulgaria	0.161912	Accra, Ghana	0.128546	Burgas, Bulgaria	0.097147
Burgas, Bulgaria	0.208462	Sigonella AB, Italy	0.159827	Burgas, Bulgaria	0.125077	Sigonella AB, Italy	0.095896
Incirlik AB, Turkey	0.198497	Accra, Ghana	0.111353	Incirlik AB, Turkey	0.119098	Accra, Ghana	0.066812
Thumrait, Oman	0.149921	Kuwait IAP, Kuwait	0.107094	Thumrait, Oman	0.089953	Kuwait IAP, Kuwait	0.064257
Seeb Intl, Oman	0.140278	Thumrait, Oman	0.100195	Seeb Intl, Oman	0.084167	Thumrait, Oman	0.060117
Kuwait IAP, Kuwait	0.139368	Ali Al Salem, Kuwait	0.099653	Kuwait IAP, Kuwait	0.083621	Ali Al Salem, Kuwait	0.059792
Libreville, Gabon	0.138637	Bahrain Intl, Bahrain	0.090384	Libreville, Gabon	0.083182	Bahrain Intl, Bahrain	0.05423
Entebbe Intl, Uganda	0.13115	Al Udeid AB, Qatar	0.089768	Entebbe Intl, Uganda	0.07869	Al Udeid AB, Qatar	0.053861
Ali Al Salem, Kuwait	0.130506	U-Taphao Intl, Thailand	0.088769	Ali Al Salem, Kuwait	0.078303	U-Taphao Intl, Thailand	0.053261
Bahrain Intl, Bahrain	0.128262	Seeb Intl, Oman	0.083666	Bahrain Intl, Bahrain	0.076957	Seeb Intl, Oman	0.050199
Al Udeid AB, Qatar	0.122316	Libreville, Gabon	0.082286	Al Udeid AB, Qatar	0.07339	Libreville, Gabon	0.049371
U-Taphao Intl, Thailand	0.094523	Entebbe Intl, Uganda	0.077684	U-Taphao Intl, Thailand	0.056714	Entebbe Intl, Uganda	0.04661
Moi, Kenya	0.053934	Diego Garcia, B.I.O.T	0.029787	Moi, Kenya	0.03236	Diego Garcia, B.I.O.T	0.017872
Diego Garcia, B.I.O.T	0.04677	Moi, Kenya	0.028372	Diego Garcia, B.I.O.T	0.028062	Moi, Kenya	0.017023
Lusaka, Zambia	0.038108	Lusaka, Zambia	0.022791	Lusaka, Zambia	0.022865	Lusaka, Zambia	0.013674

Table 2. Results for Original Model and Experiments 1-3-Lahore, Pakistan.

Original Preference Structure		Experiment 1		Experiment 2		Experiment 3	
		Adjusted Preference Strucutre		Weighted CONUS Origins		Combinations of Experiments 1 and 2	
		Throughput (.7), Sustainment (.3)					
en routes	scores	en routes	scores	en routes	scores	en routes	scores
RAF Fairford, England	0.443633	RAF Fairford, England	0.424659	RAF Fairford, England	0.446304	RAF Fairford, England	0.432137
Ramstein AB, Germany	0.331451	Ramstein AB, Germany	0.249682	Ramstein AB, Germany	0.280567	Ramstein AB, Germany	0.215748
Mildenhall AB, United Kingdom	0.293863	Mildenhall AB, United Kingdom	0.227645	Mildenhall AB, United Kingdom	0.248263	Mildenhall AB, United Kingdom	0.195191
Spangdahlem AB, Germany	0.269161	Spangdahlem AB, Germany	0.214696	Spangdahlem AB, Germany	0.161497	Spangdahlem AB, Germany	0.128817
Constanta, Romania	0.242565	Constanta, Romania	0.177883	Constanta, Romania	0.145539	Constanta, Romania	0.10673
Sigonella AB, Italy	0.233173	Misawa AB, Japan	0.175927	Sigonella AB, Italy	0.139904	Misawa AB, Japan	0.105556
Misawa AB, Japan	0.230356	Yokota AB, Japan	0.175916	Misawa AB, Japan	0.138214	Yokota AB, Japan	0.10555
Yokota AB, Japan	0.212638	Incirlik AB, Turkey	0.168283	Yokota AB, Japan	0.127583	Incirlik AB, Turkey	0.10097
Burgas, Bulgaria	0.209124	Burgas, Bulgaria	0.163767	Burgas, Bulgaria	0.125475	Burgas, Bulgaria	0.09826
Incirlik AB, Turkey	0.196781	Sigonella AB, Italy	0.163731	Incirlik AB, Turkey	0.118069	Sigonella AB, Italy	0.098238
Iwakuni MCAS, Japan	0.156696	Iwakuni MCAS, Japan	0.144845	Iwakuni MCAS, Japan	0.094017	Iwakuni MCAS, Japan	0.086907
Thumrait, Oman	0.155876	Kuwait IAP, Kuwait	0.117952	Thumrait, Oman	0.093526	Kuwait IAP, Kuwait	0.070771
Seeb Intl, Oman	0.151097	Thumrait, Oman	0.116867	Seeb Intl, Oman	0.090658	Thumrait, Oman	0.07012
Kuwait IAP, Kuwait	0.143246	Seeb Intl, Oman	0.113959	Kuwait IAP, Kuwait	0.085947	Seeb Intl, Oman	0.068376
Bahrain Intl, Bahrain	0.135038	Al Udeid AB, Qatar	0.110818	Bahrain Intl, Bahrain	0.081023	Al Udeid AB, Qatar	0.066491
Ali Al Salem, Kuwait	0.13392	Bahrain Intl, Bahrain	0.109358	Ali Al Salem, Kuwait	0.080352	Bahrain Intl, Bahrain	0.065615
Entebbe Intl, Uganda	0.132132	Ali Al Salem, Kuwait	0.109215	Entebbe Intl, Uganda	0.079279	Ali Al Salem, Kuwait	0.065529
Al Udeid AB, Qatar	0.129834	Kadena AB, Japan	0.081889	Al Udeid AB, Qatar	0.0779	Kadena AB, Japan	0.049133
Kadena AB, Japan	0.111148	Entebbe Intl, Uganda	0.080434	Kadena AB, Japan	0.066689	Entebbe Intl, Uganda	0.04826
Clark AB, Philippines	0.110366	U-Taphao Intl, Thailand	0.077262	Clark AB, Philippines	0.06622	U-Taphao Intl, Thailand	0.046357
Paya Lebar, Singapore	0.103652	Clark AB, Philippines	0.071432	Paya Lebar, Singapore	0.062191	Clark AB, Philippines	0.042859
Changi, Singapore	0.10217	Mactan Intl,Philippines	0.065715	Changi, Singapore	0.061302	Mactan Intl,Philippines	0.039429
Mactan Intl,Philippines	0.100452	Paya Lebar, Singapore	0.064532	Mactan Intl,Philippines	0.060271	Paya Lebar, Singapore	0.038719
U-Taphao Intl, Thailand	0.090414	Changi, Singapore	0.059398	U-Taphao Intl, Thailand	0.054248	Changi, Singapore	0.035639
Moi, Kenya	0.054484	Diego Garcia, B.I.O.T	0.046454	Moi, Kenya	0.03269	Diego Garcia, B.I.O.T	0.027872
Diego Garcia, B.I.O.T	0.052723	Moi, Kenya	0.029912	Diego Garcia, B.I.O.T	0.031634	Moi, Kenya	0.017947

Table 3. Results for Original Model and Experiments 1-3-Dili, Indonesia.

Original Preference Structure		Experiment 1		Experiment 2		Experiment 3	
		Adjusted Preference Strucutre		Weighted CONUS Origins		Combinations of Experiments 1 and 2	
		Throughput (.7), Sustainment (.3)					
en routes	scores	en routes	scores	en routes	scores	en routes	scores
Misawa AB, Japan	0.227651	Misawa AB, Japan	0.168354	Misawa AB, Japan	0.136591	Misawa AB, Japan	0.101012
Yokota AB, Japan	0.205708	Thumrait, Oman	0.160306	Yokota AB, Japan	0.123425	Thumrait, Oman	0.096184
Thumrait, Oman	0.17139	Yokota AB, Japan	0.156514	Thumrait, Oman	0.102834	Yokota AB, Japan	0.093908
Seeb Intl, Oman	0.161947	Seeb Intl, Oman	0.144341	Seeb Intl, Oman	0.097168	Seeb Intl, Oman	0.086605
Iwakuni MCAS, Japan	0.151956	Iwakuni MCAS, Japan	0.131572	Iwakuni MCAS, Japan	0.091173	Iwakuni MCAS, Japan	0.078943
Anderson AB, Guam	0.143414	Anderson AB, Guam	0.117959	Anderson AB, Guam	0.086048	Anderson AB, Guam	0.070775
Darwin, Australia	0.11889	Paya Lebar, Singapore	0.083511	Darwin, Australia	0.071334	Paya Lebar, Singapore	0.050106
Clark AB, Philippines	0.11272	Changi, Singapore	0.078532	Clark AB, Philippines	0.067632	Changi, Singapore	0.047119
Paya Lebar, Singapore	0.11043	Clark AB, Philippines	0.078024	Paya Lebar, Singapore	0.066258	Clark AB, Philippines	0.046814
Changi, Singapore	0.109004	Mactan Intl,Philippines	0.076877	Changi, Singapore	0.065402	Mactan Intl,Philippines	0.046126
Kadena AB, Japan	0.108422	U-Taphao Intl, Thailand	0.075315	Kadena AB, Japan	0.065053	U-Taphao Intl, Thailand	0.045189
Mactan Intl,Philippines	0.104438	Kadena AB, Japan	0.074255	Mactan Intl,Philippines	0.062663	Kadena AB, Japan	0.044553
U-Taphao Intl, Thailand	0.089719	Darwin, Australia	0.063819	U-Taphao Intl, Thailand	0.053831	Darwin, Australia	0.038292
Diego Garcia, B.I.O.T	0.049819	Diego Garcia, B.I.O.T	0.038323	Diego Garcia, B.I.O.T	0.029891	Diego Garcia, B.I.O.T	0.022994

Table 4. Results for Original Model and Experiments 1-3-Gao, India.

Original Preference Structure		Experiment 1		Experiment 2		Experiment 3	
		Adjusted Preference Strucutre Throughput (.7), Sustainment (.3)		Weighted CONUS Origins		Combinations of Experiments 1 and 2	
en routes	scores	en routes	scores	en routes	scores	en routes	scores
Constanta, Romania	0.243957	Sigonella AB, Italy	0.190684	Constanta, Romania	0.146374	Sigonella AB, Italy	0.11441
Sigonella AB, Italy	0.242799	Constanta, Romania	0.181779	Sigonella AB, Italy	0.14568	Constanta, Romania	0.109067
Burgas, Bulgaria	0.211145	Incirlik AB, Turkey	0.173898	Burgas, Bulgaria	0.126687	Incirlik AB, Turkey	0.104339
Incirlik AB, Turkey	0.198786	Burgas, Bulgaria	0.169426	Incirlik AB, Turkey	0.119272	Burgas, Bulgaria	0.101656
Thumrait, Oman	0.16459	Iwakuni MCAS, Japan	0.142167	Thumrait, Oman	0.098754	Iwakuni MCAS, Japan	0.0853
Seeb Intl, Oman	0.157793	Thumrait, Oman	0.141266	Seeb Intl, Oman	0.094676	Thumrait, Oman	0.08476
Iwakuni MCAS, Japan	0.155739	Seeb Intl, Oman	0.132708	Iwakuni MCAS, Japan	0.093444	Seeb Intl, Oman	0.079625
Kuwait IAP, Kuwait	0.14681	Kuwait IAP, Kuwait	0.127933	Kuwait IAP, Kuwait	0.088086	Kuwait IAP, Kuwait	0.07676
Bahrain Intl, Bahrain	0.139999	Al Udeid AB, Qatar	0.126177	Bahrain Intl, Bahrain	0.084	Al Udeid AB, Qatar	0.075706
Ali Al Salem, Kuwait	0.137456	Bahrain Intl, Bahrain	0.123249	Ali Al Salem, Kuwait	0.082473	Bahrain Intl, Bahrain	0.073949
Al Udeid AB, Qatar	0.135319	Ali Al Salem, Kuwait	0.119113	Al Udeid AB, Qatar	0.081192	Ali Al Salem, Kuwait	0.071468
Entebbe Intl, Uganda	0.132461	U-Taphao Intl, Thailand	0.08944	Entebbe Intl, Uganda	0.079476	U-Taphao Intl, Thailand	0.053664
Kadena AB, Japan	0.112622	Kadena AB, Japan	0.086013	Kadena AB, Japan	0.067573	Kadena AB, Japan	0.051608
Clark AB, Philippines	0.112612	Entebbe Intl, Uganda	0.081354	Clark AB, Philippines	0.067567	Entebbe Intl, Uganda	0.048812
Paya Lebar, Singapore	0.107417	Clark AB, Philippines	0.077721	Paya Lebar, Singapore	0.06445	Clark AB, Philippines	0.046633
Changi, Singapore	0.105926	Paya Lebar, Singapore	0.075073	Changi, Singapore	0.063555	Paya Lebar, Singapore	0.045044
Mactan Intl,Philippines	0.102531	Mactan Intl,Philippines	0.071537	Mactan Intl,Philippines	0.061519	Mactan Intl,Philippines	0.042922
U-Taphao Intl, Thailand	0.094763	Changi, Singapore	0.069915	U-Taphao Intl, Thailand	0.056858	Changi, Singapore	0.041949
Moi, Kenya	0.053934	Diego Garcia, B.I.O.T	0.029787	Moi, Kenya	0.03236	Diego Garcia, B.I.O.T	0.017872
Diego Garcia, B.I.O.T	0.04677	Moi, Kenya	0.028372	Diego Garcia, B.I.O.T	0.028062	Moi, Kenya	0.017023
Lusaka, Zambia	0.038628	Lusaka, Zambia	0.024245	Lusaka, Zambia	0.023177	Lusaka, Zambia	0.014547

Table 5. Results for Original Model and Experiments 1-3-Seoul, Republic of Korea.

Original Preference Structure		Experiment 1		Experiment 2		Experiment 3	
		Adjusted Preference Strucutre		Weighted CONUS Origins		Combinations of Experiments 1 and 2	
		Throughput (.7), Sustainment (.3)					
en routes	scores	en routes	scores	en routes	scores	en routes	scores
Elmendorf AFB, Alaska	0.395527	Elmendorf AFB, Alaska	0.304571	Elmendorf AFB, Alaska	0.515609	Elmendorf AFB, Alaska	0.411401
Misawa AB, Japan	0.225421	Yokota AB, Japan	0.165157	Misawa AB, Japan	0.135252	Yokota AB, Japan	0.099094
Yokota AB, Japan	0.208795	Misawa AB, Japan	0.162108	Yokota AB, Japan	0.125277	Misawa AB, Japan	0.097265
Iwakuni MCAS, Japan	0.154891	Iwakuni MCAS, Japan	0.139793	Iwakuni MCAS, Japan	0.092935	Iwakuni MCAS, Japan	0.083876
Anderson AB, Guam	0.136231	Anderson AB, Guam	0.097847	Anderson AB, Guam	0.081739	Anderson AB, Guam	0.058708
Darwin, Australia	0.115836	Kadena AB, Japan	0.071933	Darwin, Australia	0.069501	Kadena AB, Japan	0.04316
Kadena AB, Japan	0.107593	U-Taphao Intl, Thailand	0.061737	Kadena AB, Japan	0.064556	U-Taphao Intl, Thailand	0.037042
Clark AB, Philippines	0.104348	Paya Lebar, Singapore	0.059158	Clark AB, Philippines	0.062609	Paya Lebar, Singapore	0.035495
Paya Lebar, Singapore	0.101733	Darwin, Australia	0.055268	Paya Lebar, Singapore	0.06104	Darwin, Australia	0.033161
Changi, Singapore	0.100251	Clark AB, Philippines	0.054581	Changi, Singapore	0.06015	Clark AB, Philippines	0.032748
Mactan Intl,Philippines	0.094785	Changi, Singapore	0.054024	Mactan Intl,Philippines	0.056871	Changi, Singapore	0.032415
U-Taphao Intl, Thailand	0.084869	Mactan Intl,Philippines	0.049848	U-Taphao Intl, Thailand	0.050921	Mactan Intl,Philippines	0.029909

Table 6. Results for Original Model and Experiments 1-3-Waterkloof, South Africa.

Original Preference Structure		Experiment 1		Experiment 2		Experiment 3	
		Adjusted Preference Strucutre		Weighted CONUS Origins		Combinations of Experiments 1 and 2	
		Throughput (.7), Sustainment (.3)					
en routes	scores	en routes	scores	en routes	scores	en routes	scores
Accra, Ghana	0.227193977	Accra, Ghana	0.147616048	Accra, Ghana	0.136316	Accra, Ghana	0.08857
Libreville, Gabon	0.157519967	Libreville, Gabon	0.13515922	Libreville, Gabon	0.094512	Libreville, Gabon	0.081096
Seeb Intl, Oman	0.148497923	Kuwait IAP, Kuwait	0.124519008	Seeb Intl, Oman	0.089099	Kuwait IAP, Kuwait	0.074711
Entebbe Intl, Uganda	0.14633289	Entebbe Intl, Uganda	0.120196011	Entebbe Intl, Uganda	0.0878	Entebbe Intl, Uganda	0.072118
Kuwait IAP, Kuwait	0.14559098	Ali Al Salem, Kuwait	0.116141243	Kuwait IAP, Kuwait	0.087355	Ali Al Salem, Kuwait	0.069685
Ali Al Salem, Kuwait	0.136394282	Bahrain Intl, Bahrain	0.108905064	Ali Al Salem, Kuwait	0.081837	Bahrain Intl, Bahrain	0.065343
Bahrain Intl, Bahrain	0.134876337	Al Udeid AB, Qatar	0.108541568	Bahrain Intl, Bahrain	0.080926	Al Udeid AB, Qatar	0.065125
Al Udeid AB, Qatar	0.12902103	Seeb Intl, Oman	0.106682603	Al Udeid AB, Qatar	0.077413	Seeb Intl, Oman	0.06401
Ascension AUX AF, Ascension	0.116806839	Ascension AUX AF, Ascension	0.069228269	Ascension AUX AF, Ascension	0.070084	Ascension AUX AF, Ascension	0.041537
Moi, Kenya	0.059180148	Moi, Kenya	0.043062394	Moi, Kenya	0.035508	Moi, Kenya	0.025837
Diego Garcia, B.I.O.T	0.046770273	Lusaka, Zambia	0.039420516	Diego Garcia, B.I.O.T	0.028062	Lusaka, Zambia	0.023652
Lusaka, Zambia	0.044047485	Diego Garcia, B.I.O.T	0.029786999	Lusaka, Zambia	0.026428	Diego Garcia, B.I.O.T	0.017872

Table 7. Results for Original Model and Experiments 1-3-Monrovia, Liberia.

Original Preference Structure		Experiment 1		Experiment 2		Experiment 3	
		Adjusted Preference Strucutre		Weighted CONUS Origins		Combinations of Experiments 1 and 2	
		Throughput (.7), Sustainment (.3)					
en routes	scores	en routes	scores	en routes	scores	en routes	scores
RAF Fairford, England	0.41191	RAF Fairford, England	0.335836	Roosevelt Roads, Puerto Rico	0.505352	Roosevelt Roads, Puerto Rico	0.362225
Roosevelt Roads, Puerto Rico	0.356491	Roosevelt Roads, Puerto Rico	0.246202	RAF Fairford, England	0.413127	RAF Fairford, England	0.339243
Rota NAS, Spain	0.318543	Rota NAS, Spain	0.223288	Lajes, Portugal	0.324644	Rota NAS, Spain	0.185427
Ramstein AB, Germany	0.314105	Moron AB, Spain	0.207348	Rota NAS, Spain	0.266814	Lajes, Portugal	0.184401
Moron AB, Spain	0.299203	Dakar, Senegal	0.202722	Ramstein AB, Germany	0.264818	Dakar, Senegal	0.180364
Lajes, Portugal	0.298647	Ramstein AB, Germany	0.201115	Augusto Severo, Brazil	0.260012	Augusto Severo, Brazil	0.172737
Dakar, Senegal	0.272255	Spangdahlem AB, Germany	0.181202	Moron AB, Spain	0.250633	Moron AB, Spain	0.172218
Mildenhall AB, United Kingdom	0.270714	Lajes, Portugal	0.165284	Dakar, Senegal	0.232293	Ramstein AB, Germany	0.171651
Spangdahlem AB, Germany	0.257199	Mildenhall AB, United Kingdom	0.162827	Mildenhall AB, United Kingdom	0.227046	Mildenhall AB, United Kingdom	0.135784
Constanta, Romania	0.231769	Constanta, Romania	0.147654	Spangdahlem AB, Germany	0.154319	Spangdahlem AB, Germany	0.108721
Sigonella AB, Italy	0.225999	Sigonella AB, Italy	0.143642	Constanta, Romania	0.139062	Constanta, Romania	0.088592
Accra, Ghana	0.22543	Accra, Ghana	0.142678	Sigonella AB, Italy	0.135599	Sigonella AB, Italy	0.086185
Augusto Severo, Brazil	0.211892	Incirlik AB, Turkey	0.135921	Accra, Ghana	0.135258	Accra, Ghana	0.085607
Burgas, Bulgaria	0.198316	Burgas, Bulgaria	0.133505	Burgas, Bulgaria	0.11899	Incirlik AB, Turkey	0.081553
Incirlik AB, Turkey	0.185223	Augusto Severo, Brazil	0.130552	Incirlik AB, Turkey	0.111134	Burgas, Bulgaria	0.080103
Libreville, Gabon	0.141603	Libreville, Gabon	0.090591	Libreville, Gabon	0.084962	Libreville, Gabon	0.054355
Entebbe Intl, Uganda	0.131435	Entebbe Intl, Uganda	0.078483	Entebbe Intl, Uganda	0.078861	Entebbe Intl, Uganda	0.04709
Ascension AUX AF, Ascension	0.11219	Ascension AUX AF, Ascension	0.0563	Ascension AUX AF, Ascension	0.067314	Ascension AUX AF, Ascension	0.03378
Moi, Kenya	0.054878	Moi, Kenya	0.031016	Moi, Kenya	0.032927	Moi, Kenya	0.01861
Lusaka, Zambia	0.038108	Lusaka, Zambia	0.022791	Lusaka, Zambia	0.022865	Lusaka, Zambia	0.013674

Table 8. Results for Original Model and Experiments 1-3-Bahia Blanca, Argentina.

Original Preference Structure		Experiment 1		Experiment 2		Experiment 3	
		Adjusted Preference Strucutre		Weighted CONUS Origins		Combinations of Experiments 1 and 2	
		Throughput (.7), Sustainment (.3)					
en routes	scores	en routes	scores	en routes	scores	en routes	scores
Roosevelt Roads, Puerto Rico	0.365525	Roosevelt Roads, Puerto Rico	0.271499	Roosevelt Roads, Puerto Rico	0.515025	Roosevelt Roads, Puerto Rico	0.38931
Augusto Severo, Brazil	0.221247	Augusto Severo, Brazil	0.156745	Augusto Severo, Brazil	0.263368	Augusto Severo, Brazil	0.182134
Ascension AUX AF, Ascension	0.119847	Ascension AUX AF, Ascension	0.077742	Ascension AUX AF, Ascension	0.071908	Ascension AUX AF, Ascension	0.046645

Appendix E. Graphic Results Comparison
Experiments 1 Through 3

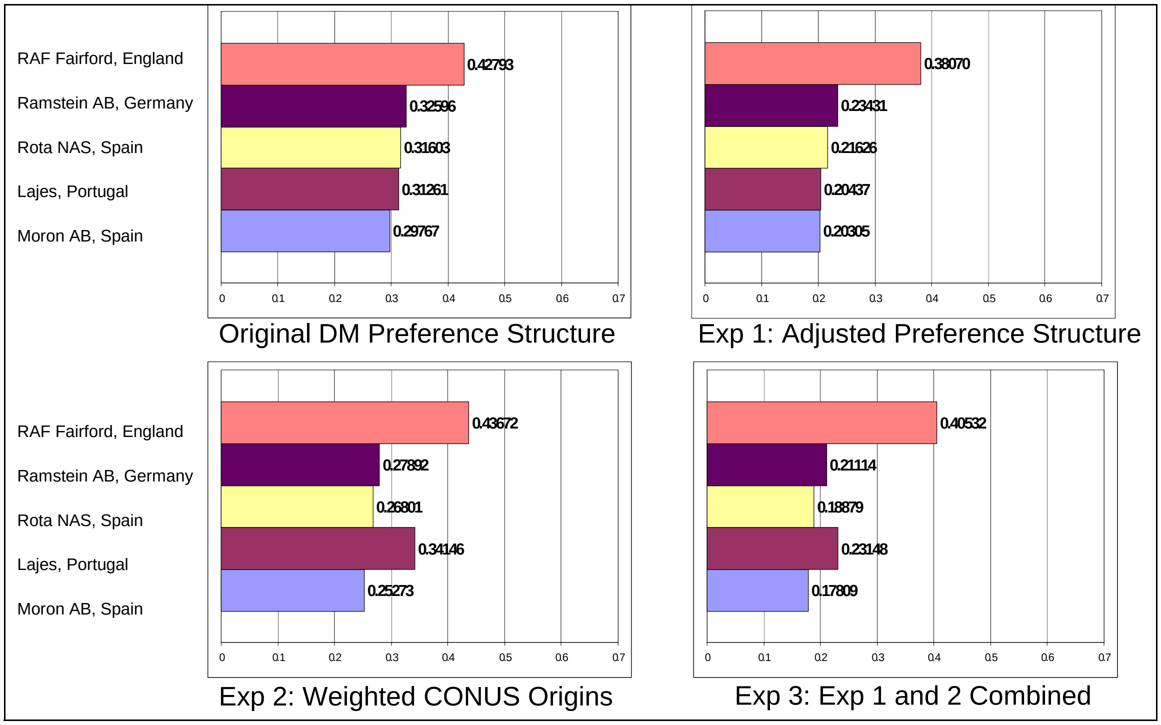


Figure 1. Destination1: Baghdad International, Iraq.

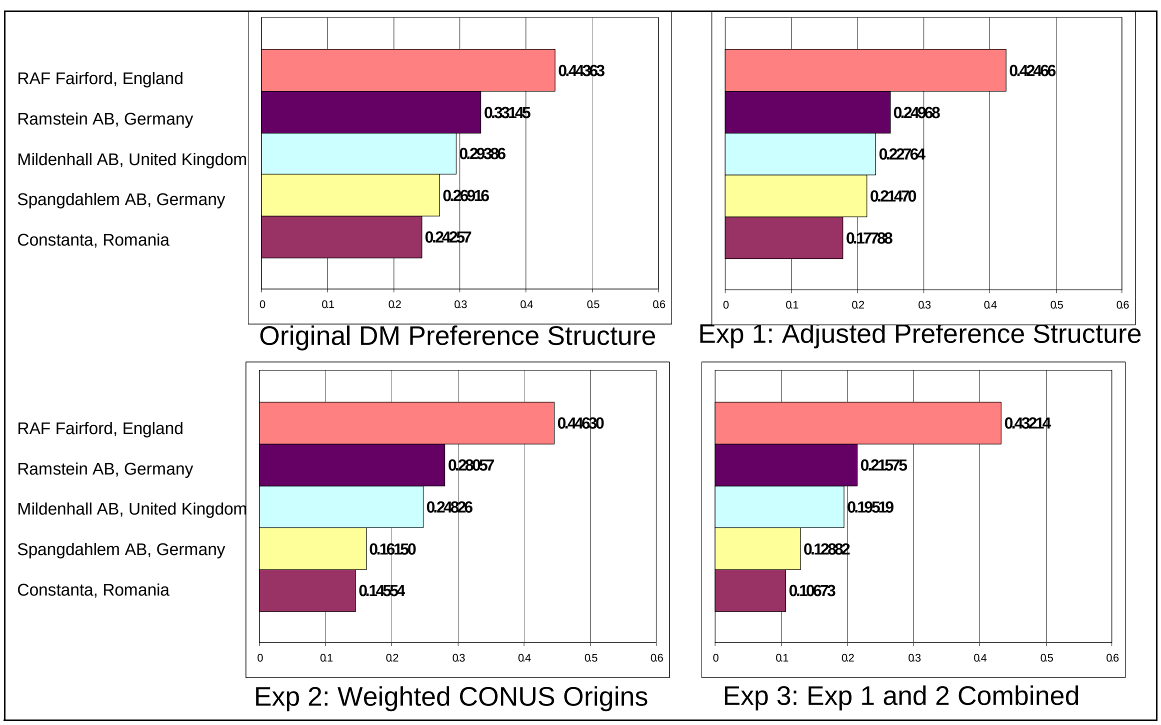


Figure 2. Destination 2: Lahore, Pakistan.

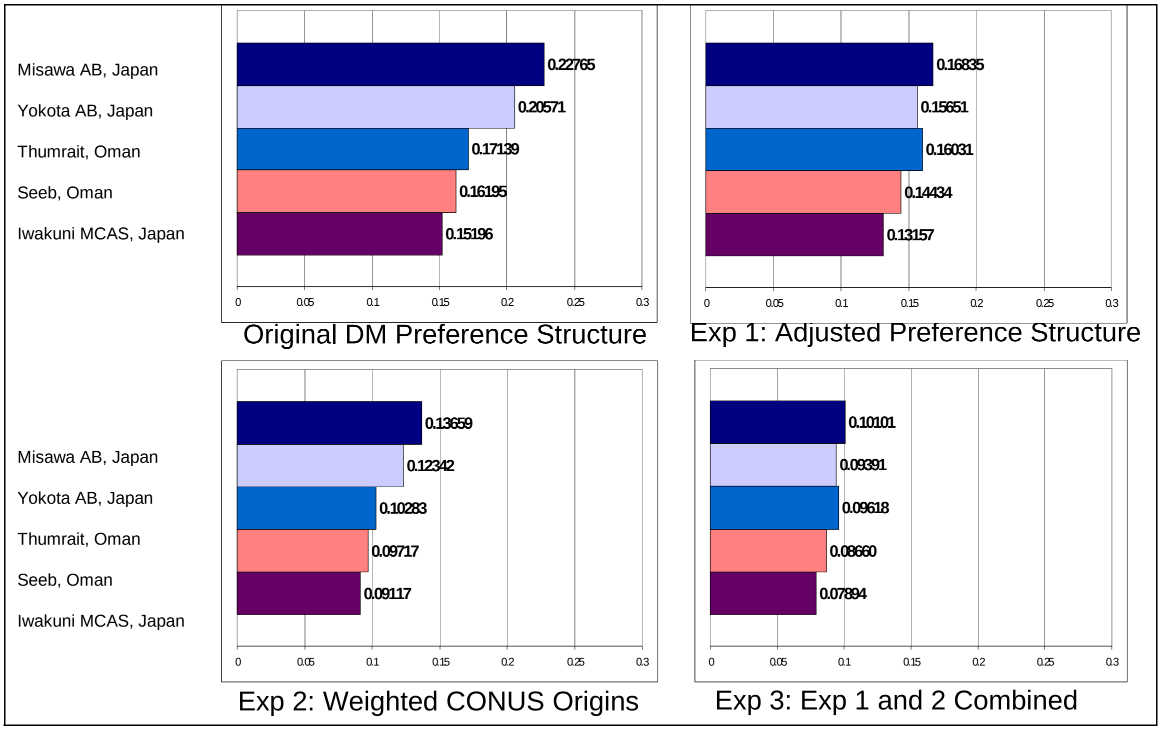
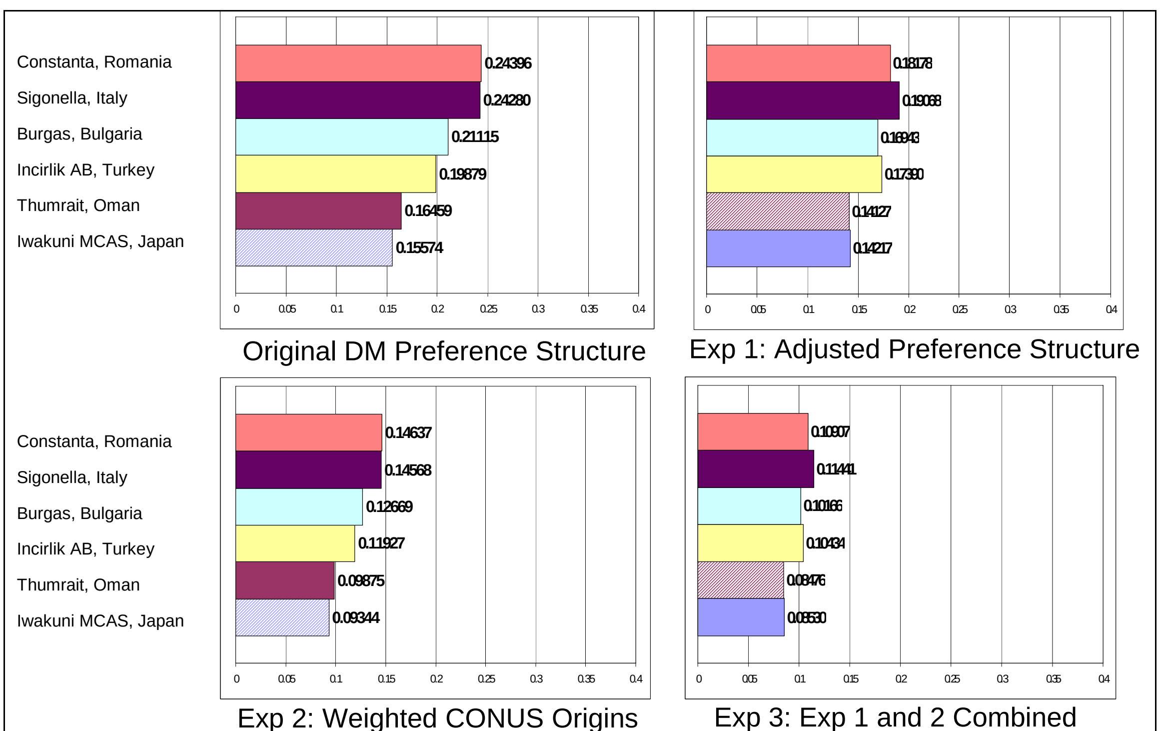


Figure 3. Destination 3: Dili, Indonesia.



Note: Striped bars-airfield is not ranked in the top five for the associated experiment.

Figure 4. Destination 4: Gao, India.

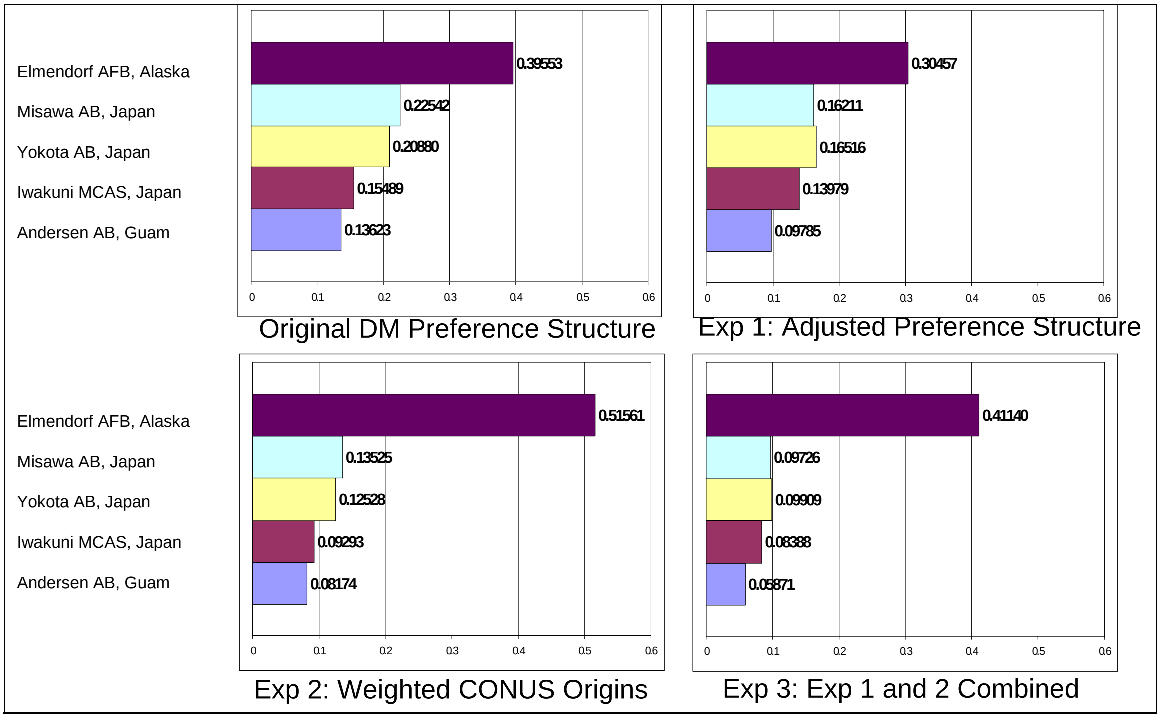
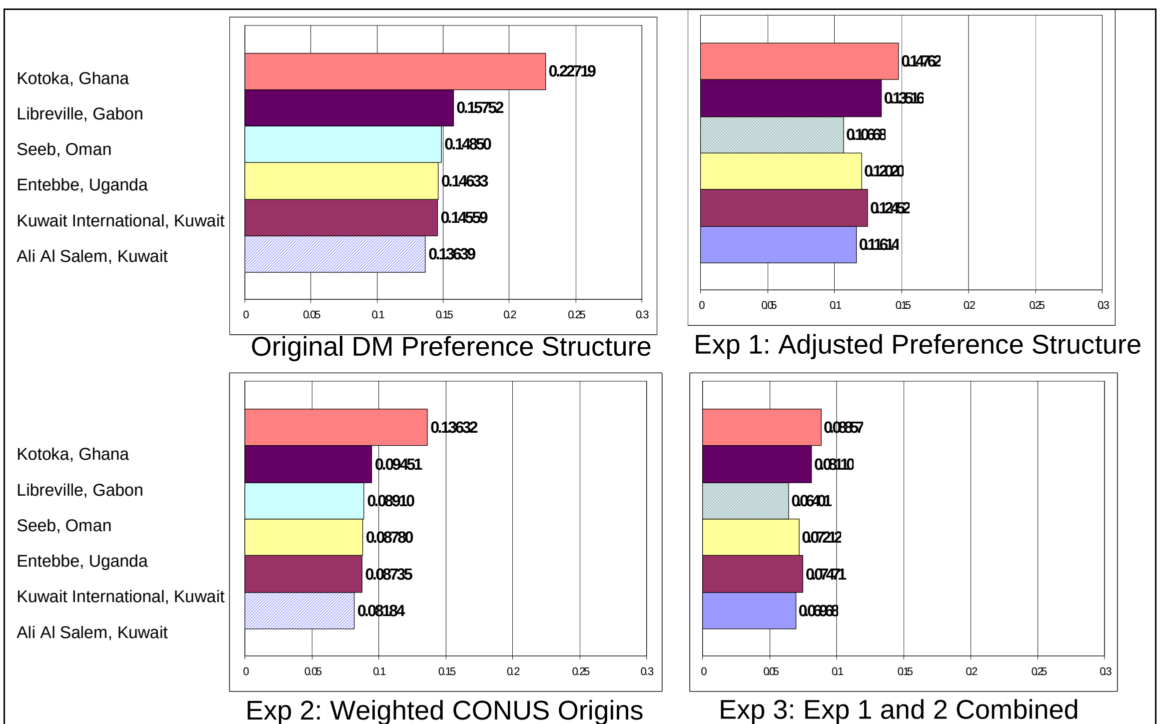
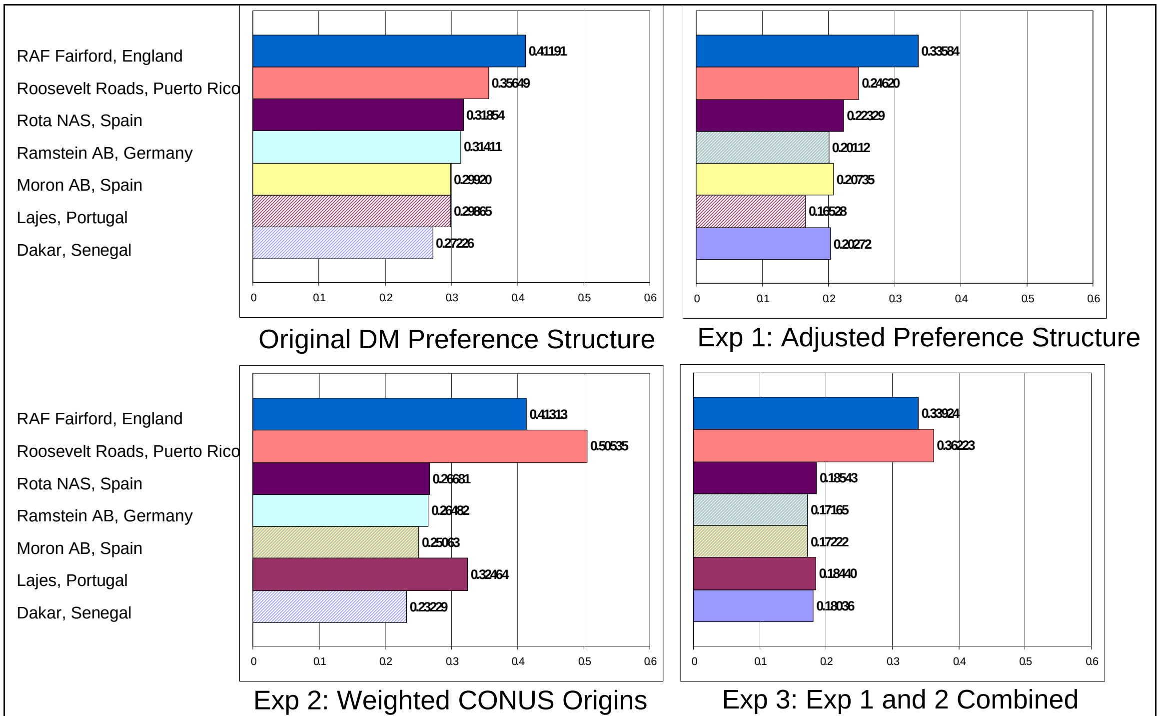


Figure 5. Destination 5: Seoul, Republic of Korea.



Note: Striped bars-airfield is not ranked in the top five for the associated experiment.

Figure 6. Destination 6: Waterkloof, South Africa.



Note: Striped bars-airfield is not ranked in the top five for the associated experiment.

Figure 7. Destination 7: Monrovia, Liberia.

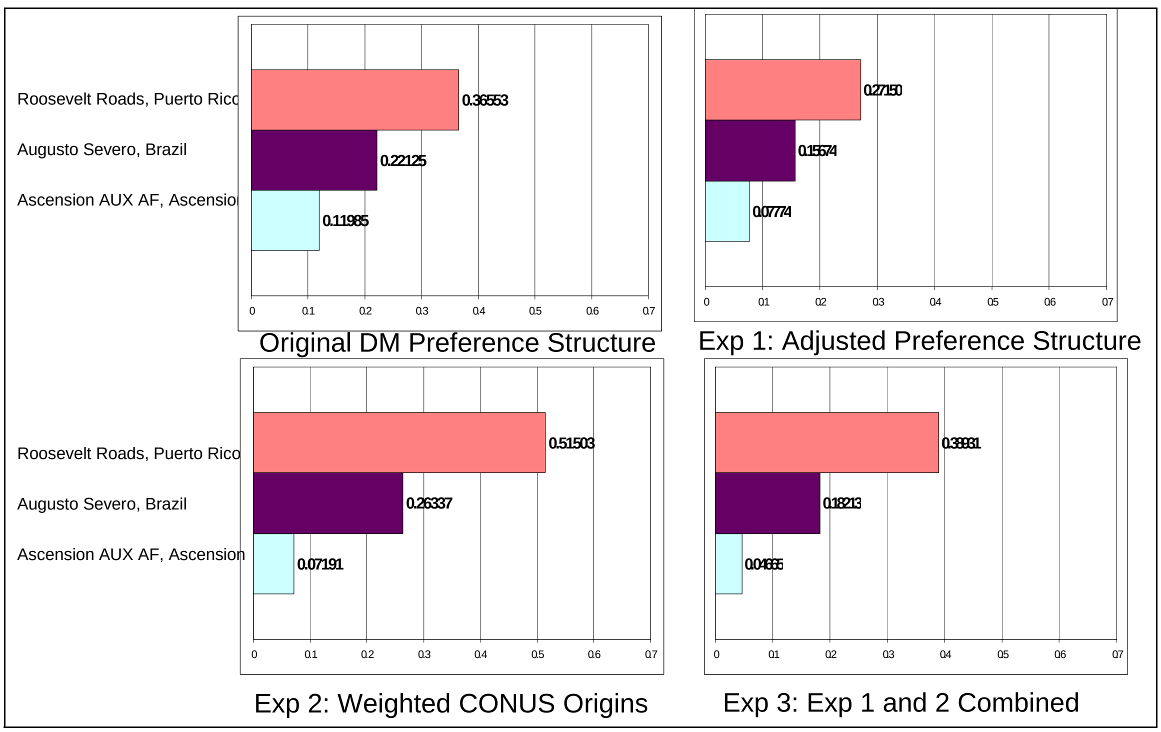


Figure 8. Destination 8: Bahia Blanca, Argentina.

Bibliography

Air Mobility Command, "Airfield Suitability Database." On-line database. n. pag. https://www.afd.scott.af.mil. 15 December 2005.

Anderson, D, Sweeney, D, and Williams,T. *An Introduction to Management Science: Quantitative Approaches to Decision Making*, Mason, OH: South-Western, 2003.

Air Force Studies and Analysis Agency, Future Capabilities Branch, "Capability-Based Logistics Planner" 8 February 2006.

Central Intelligence Agency, "The World Factbook." On-line database. n. pag. http://www.cia.gov. 15 December 2005.

Clemen, R. and T. Reilly. *Making Hard Decisions with DecisionTools 2004*, Pacific Grove, CA: Duxbury, 2001.

Lockheed Martin Warlab. Airfield Reference Program, 15 December 2005.

Greenstreet, K. *Examination of Optimal Range/Payload Metrics for Strategic Airlift Aircraft*, USAF IDE Graduate Research Paper, AFIT/GOS/ENS/04-06. School of Engineering and Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 2004.

Hoare, R. "World Climate: Weather, Rainfall, and Temperature Data." On-line database. n. pag. http://www.worldclimate.com, 15 January 2006.

Keeney, R. *Value Focused Thinking: A Path to Creative Decision Making*, Cambridge, MA: Harvard University Press, 1992.

Kirkwood, C. *Strategic Decision Making: Multiobjective Decision Analysis with Spreadsheets*, Belmont, CA: Wadsworth Publishing Company, 1997.

McVicker, P. "En Route Strategic Plan" Report to USTRANSCOM/J5, Scott AFB IL: AMC/XP, February 2002.

Miravite, Alexander, Maj, USAF, Personal Interviews, Multiple Dates, Nov 2005 – Feb 2006.

North Atlantic Treaty Organization website, http://www.nato.int. 20 January 2006.

Reckamp, K. and Others. "Interim Brigade Combat Team Air Mobility Deployment Analysis", Military Traffic Management Command, Transportation Engineering Agency, USTRANSCOM/J5, and AMC, April 2002.

Schlegel, Charles F., Maj, USAF, Personal Interviews, Multiple Dates, Nov 2005–Feb 2006.

Sere, M. *Strategic Airlift En Route Analysis and Considerations to Support the Global War on Terrorism*, MS thesis, AFIT/GOR/ENS/05-17. School of Engineering and Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, March 2005.

Shoviak, M. *Decision Analysis Method to Evaluate Integrated Solid Waste Management Alternatives for a Remote Alaskan Air Station*, MS thesis, AFIT/GEE/ENV/01M-02. School of Engineering and Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, March 2001.

Swartz, K. "Great Circle Mapper Utility Tool." http://gc.kls2.com. 15 December 2005.

United Nations website, http://www.un.org. 20 January 2006.

United States Air Force, *Air Mobility Planning Factors*, AFPAM 10-1403, Washington: HQ USAF, 18 December 2003.

U.S. Department of State website, http://www.state.gov/r/pa/ei/bgn. 19 December 2005.

United States General Accounting Office, "MILITARY READINESS: Management Focus Needed on Airfields for Overseas Deployments," GAO-01-566, Washington: Government Printing Office, June 2001.

Voight, Jeanette M. *Optimization of Strategic Airlift En Route Throughput to Support the Global War on Terrorism*, USAF IDE Graduate Research Paper, AFIT/GMO/ENS/05-E15. School of Engineering and Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, May 2005.

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14. ABSTRACT

The Global War on Terrorism (GWOT) has yielded new challenges to the United States' strategic airlift infrastructure. The network of en-route airfields that serve as refueling and maintenance stops were designed primarily to service relatively static Cold War requirements. However, the GWOT has resulted in the need for an infrastructure that is responsive to a highly dynamic environment. This research uses a "value focused" methodology to identify en-route airfield locations that simultaneously maximize cargo throughput capability while possessing a high degree of adaptability to volatile cargo delivery requirements.

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