The Impact of Long-Run CRAF Activation Risk

On International Routes

GRADUATE RESEARCH PROJECT

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Abstract

The Civil Reserve Air Fleet (CRAF) provides a large amount of cargo and passenger capacity to the Department of Defense (DoD) during peacetime and times of war. Participation in the CRAF program is completely voluntary and the airlines that do participate risk economic hardships if the CRAF fleet is activated. CRAF network carriers provide 90 percent of passenger capacity for peacetime and contingency operations and in 2010, full Stage III activation represented 32 percent of the airline industry's passenger capability, and over 35 percent of the available cargo capacity. If just 25 percent of the CRAF passenger capacity was activated, the potential impact in passenger markets could be staggering. The impact on commercial markets of the CRAF activation in 1991 caused multiple carriers to pull out of the program or reduce their commitment. It is important to understand whether the risk of activation impact participation levels so that the DoD can tailor CRAF incentives to maintain capacity to meet wartime requirements.

This research used publicly available data, collected by the U.S. Department of Transportation, on international flights from specific U.S. airports. The data contained information on market share, number of competitors, level of competition, type of aircraft used and the load factor for all airlines (U.S. and foreign) from May 2009 to May 2010. In addition CRAF commitment data for each airline was compiled from Air Mobility Command. The aggregation of this data was used to create a model to predict risk scores based on the amount of aircraft committed to the CRAF and the type of aircraft being flown on specific routes. This risk score was then compared to variables such as market share, load factor and foreign competition

to determine if a positive or negative relationship between the variables existed. The study found that market share, the number of foreign carriers, the operating airline and the operating route, country and region all affect the risk assumed during CRAF activation.

The analysis of the data shows that there were U.S. airlines that could be considered at significant risk if CRAF was activated. The study also highlighted certain strategic routes that are highly valuable to specific U.S. airlines that could cause economic hardships if lost due to activation. The Department of Defense and U.S. Transportation Command should be aware of these possible negative effects on the airlines and how their economic viability affects military readiness.

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I. Introduction

The U.S. military is constantly looking to further its capabilities while reducing cost, materiel and personnel to operate the equipment. "Nonmilitary resources contribute inexpensive capability at a time of limited future growth in defense procurement programs, funding problems due to rising military system costs, and ever increasing capability requirements" (Chenoweth, 1990: v). The Civil Reserve Air Fleet is specifically designed in this vein; to use commercial assets in support of Department of Defense objectives. The Civil Reserve Air Fleet (CRAF) was created in 1951, but has its roots in World War II when President Roosevelt directed the Secretary of War to take control of commercial air assets to assist in the war effort. (Chenoweth, 1990: 2). Overall, the purpose of the CRAF remains the same today.

The CRAF is a program that benefits the U.S. military by increasing airlift capability using non-organic assets in time of national crisis, while providing incentives to the airlines for committing their assets. There are multiple stages and segments of the CRAF that can be activated and used to support various national objectives. The three key segments are defined by the type of airframe that is required for the mission: international (long-haul aircraft), domestic (short range assets), and aero-medical evacuation (specially configured passenger jets) (Bolkom, 2006: 1). The specific use of these assets is determined by U.S. Transportation Command (TRANSCOM) when the CRAF is activated. In addition to the three segments of CRAF, the activation is divided into three stages. Each stage represents an increased level of crisis, and thus a greater need for additional airlift requirements.

Stage I is labeled as a Committed Expansion and defined as the ability to, "support substantially expanded peacetime military requirements or a minor regional contingency" (AMCI 10-402, 2004: 17). Stage II increases the capability requirements and is known as a Defense Airlift Emergency usually activated in the case of a major theatre war. Finally, Stage III would be activated in the event of a National Emergency such as multiple theater war or a special national security situation (AMCI 10-402, 2004: 17). CRAF Stage I has only been activated twice since the inception of the program; 17 August 1990 at the start of U.S. military operations defending Kuwait and again on 8 February 2003 in support of the U.S. invasion of Iraq. Stage II was activated once, on 17 January 1991, CRAF Stage III has never been activated.

CRAF activation is a vital capability for the U.S. military providing necessary surge airlift capacity. However, the activation of commercial airlift assets has economic impacts on the individual carriers. These affects vary between the carriers and the stages of activation. For some airlines, the economic impact of activation can be significant affecting the airline's profitability, market position and market share on specific routes or to specific regions of the world.

Background and Research Focus

U.S. flagged, CRAF participating airlines are inherently linked to the global economy, and depend on international routes for a large part of their revenue. For example, in 2009 United Airlines' (UA) international passenger segment accounted for almost 34% of UA's total revenue (UA Annual Report, 2009: 110). During past

CRAF activations the smaller carriers were eager for DoD business, but the major network carriers were reluctant to participate because, “their withdrawal of equipment from commercial routes gave non-CRAF competitors an opportunity to gain long-term increases in their market shares” (Gebman, Batchelder and Poehlmann, 1994: 23).

The complete economic impact of long-term CRAF activation is unknown. The economic impact of past activations is difficult to quantify because the activation coincided with a major international event that discouraged international air travel. For example, the U.S. military operations supporting Kuwait in 1990 and 1991 coincided with an economic recession and the affect of activation versus the global economic downturn was difficult to quantify (GAO Report NSIAD 93-12, 1993: 8). Even with the difficulty in predicting the economic effect of CRAF activation, many airlines may opt out of the program if the business risk is considered too high (Graham, 2008: 8). Due to the economic stress from the 1990-1991 activation, American and United Airlines removed all of their assets from CRAF in 1994. Due to improved participation incentives they reinstated their aircraft the following year but only at the minimum participation level, and Northwest Airlines reduced their commitment from 100 percent down to the minimum 30 percent commitment level (Coffey and Frola, 1996: 3-1).

During the nine-month activation in 1990-1991, carriers lost market share to foreign carriers. Customers were compelled to sign long-term contracts with the foreign carriers when the U.S. CRAF carriers could not support their needs during the activation (GAO Report NSIAD 93-12, 1993: 8). Future extended activations could hinder the ability of certain carriers to remain competitive on certain financially lucrative routes. An in-depth study of the effects of losing specific routes or market share to international competitors is necessary to understand the full economic impact on the carriers, and ultimately the effect of possibly losing carriers from the CRAF that would adversely impact CRAF capabilities.

Although there is little empirical evidence on how the airlines are affected by the economic factors of CRAF activation we do know that network carriers are essential to CRAF viability. CRAF network carriers provide 90 percent of passenger capacity for peacetime and contingency operations (GAO Report 09-625, 2009: 10). U.S. air carriers would likely be greatly impacted by CRAF activation, with the effects growing as Stage III is approached. The author surmises that some carriers may not survive the loss of revenue without additional government funding or financing, negatively impacting CRAF capability to support Department of Defense transportation requirements. The U.S. military must have a sound understanding of how the level of CRAF activation will affect the U.S. airlines, and also how this will eventually affect U.S. military operational capabilities.

Research Question

This research investigated whether CRAF participation affected international markets for the U.S. network carriers. Specifically, this study examined whether CRAF participation increased the network carrier's level of risk on international routes and it examined which international markets had the greatest exposure or highest level of risk for the network carriers. In addressing these issues the paper's focus is on the following sub-questions:

1) Which U.S. carriers have the highest level of risk during activation?

2) Which international routes are the most at risk?

3) What are the factors/predictors of an airline/route with a high level of risk?

Implications

The U.S. military must be aware of how its decisions will affect the airlines, and in turn the overall health of the CRAF fleet. Using the data collected about routes, market share, and specific airline capability this research can aid in developing a decision model for CRAF activation. This decision model could provide TRANSCOM and Department of Transportation officials the best information to use the appropriate elements of each Stage. The economic impact of CRAF activation is important to the airlines and the Department of Defense. This study evaluated the implications of activating the CRAF and allows for informed decisions on the different levels of activation. Using this study, leaders will better understand the far-reaching impact of CRAF activation on the airlines and ultimately the Department of Defense's capabilities.

II. Literature Review

The History of the Civil Reserve Air Fleet (CRAF)

The growth of the airline industry in the early 1900's was fraught with conflict, uncertainty, and fierce competition. As airlines began interstate services, the U.S. government used its Constitutional powers to begin to regulate the industry. The earliest contracts between the U.S. government and the airline industry began with mail transportation for the Postmaster and the U.S. Army. In February 1925 the U.S. Congress created the Contract Air Mail Act, also known as the Kelly Act. This gave the postmaster general the authorization to contract with companies to transport air mail. The Kelly Act is widely accepted as the birth of the airline industry (Wensveen, 2007: 48). Walter Folger Brown, the Postmaster General at the time, wanted to use the air mail contracts to stimulate and grow a strong airline industry. The Air Mail Act of 1930 codified the Postmaster General's responsibilities and allowed for the regulation and creation of routes (Wensveen, 2007: 50). There was some political backlash with the level of control that the 1930 Act created, as well as the large amounts of money that the airline industry was making carrying mail, usually sacrificing the ability to carry passengers. In 1934 Congress enacted the Air Mail Act of 1934. This Act created competitive bidding for mail contracts, and in turn forced the airline industry to shift focus to the passenger market (CLR, 2008: 9). The industry continued to grow through the 1930's and in 1938 the government passed the Civil Aeronautics Act. This created a single entity that was responsible for the regulation and safety of the entire air transportation industry (Wensveen, 2007: 51).

The airline industry continued to grow into the years of World War II. Shortly after the attack on Pearl Harbor in December 1941, President Franklin Delano

Roosevelt directed the Secretary of War to take possession of any commercial aviation assets to assist in the war effort. "Commercial aircraft flew hundreds of missions and made significant contributions throughout World War II. Commercial transports flew military missions during the Berlin Crisis in 1948-49 when airlift was the only available means of delivering food and supplies to West Berlin" (Chenoweth, 1990: 2).

The use of commercial assets by the Department of Defense continued during the Korean War. The organic military airlift assets were insufficient for the war effort. In response to the short comings in the amount of military airlift, "The Civil Reserve Air Fleet (CRAF) was formalized through a series of presidential executive orders and memoranda of understanding, the first of which was signed December 15, 1951" (CLR, 2008: 10). The expense of maintaining a large military airlift capability, along with the flexibility that a commercial augmentation force provides was the basis for the CRAF, and remains the underlying principle to this day.

The CRAF has only been activated twice in its history, while Stage III has never been utilized. After nearly 40 years in existence the CRAF was activated for the first time in August 1990 at the start of Desert Shield. Stage I activation was coordinated with the Commander, U.S. TRANSCOM as well as with the Air Force Chief of Staff, the Secretary of the Air Force and the Secretary of Defense. Five months later Stage II was activated for the first and only time, in Jan 1991 to support Operation Desert Storm. The Stage II activation was for cargo aircraft only, and the CRAF accounted for 21% of the missions, 64% of the passengers, and 27% of the cargo during deployment. During the redeployment, CRAF carriers carried 84% of the passengers and 40% of the cargo returning to the U.S. (CLR, 2008:14). CRAF

Stage I was activated once again in Feb 2003 in support of Operation Iraqi Freedom (OIF) and flew 1,625 missions, moving 254,143 troops (CLR, 2008: 16).

CRAF Capabilities

The Air Force's Air Mobility Command (AMC) manages the Civil Reserve Air Fleet on a day-to-day basis. More specifically the DoD Commercial Airlift Division, Civil Reserve Air Fleet Branch, HQ AMC/A34BC, is responsible for the management of the CRAF program. The Commander, USTRANSCOM, with the approval of the Secretary of Defense, is the activation authority for all three stages of the CRAF. Following activation the TACC Commander is responsible for the scheduling and tracking of the CRAF assets.

There are multiple stages and segments of the CRAF that can be activated and used in different scenarios.

> The CRAF is composed of U.S. registered civil transport aircraft that are identified to satisfy long-range international, short-range international, aeromedical evacuation, domestic, and Alaskan airlift requirements. In addition, a minimum flight deck crew to aircraft ratio is required for acceptance into the CRAF. (AMCI 10-402, 2010: 12)

The three segments are defined by the type of airframe that are required for the mission: international (long-haul aircraft), domestic (short range assets), and aero medical evacuation. The international capable aircraft generally meet the standard of 3500NM range for both passenger and cargo aircraft, but as a minimum have to fly 2350NM carrying 75 percent of the aircraft's max payload. The Aeromedical Evacuation (AE) aircraft are specially configured Boeing 767 passenger jets. The long-range international aircraft that the CRAF uses must be equipped and maintained with the navigation, communications, and survival equipment for world wide extended overwater operations in accordance with Federal Aviation Regulations (FARs) (AMCI 10-402, 2010: 19).

In addition to the three segments of CRAF the activation is divided into three stages. Each stage represents an increased level of crisis, and thus a greater need for additional airlift requirements. Stage I is defined as Committed Expansion, used to support expanded peacetime operations or a small contingency operation. Stage II represents an escalated need for airlift and is defined as a Defense Airlift Emergency. This stage could support one theater war and would require domestic, international and aero medical evacuation (AE) assets. Stage III requires the most assets and is defined as a National Emergency and would require the total activation of all CRAF assets (AMCI 10-402, 2004: 17)[1].

Figure 1: FY2010 CRAF Commitments in Numbers of Aircraft by Segment/Stage

Segment		Stage		
		I	II	III
National	Domestic	-	23	36
	Alaskan	-	4	4
International	Short-Range	-	21	329
	Long-Range	72	189	763
Aero medical		-	27	39
	Total CRAF	74	264	1171

There are specific requirements for each carrier to apply for CRAF membership. The carrier must be a U.S. flag carrier, an FAA Part 121 Carrier and on a DoD-approved list of contractors. Each carrier must have one-year prior

[1] See Appendix C for CRAF participation data by airline

uninterrupted service to the commercial sector. The minimum international fleet participation levels are 15% for cargo carriers and 30% for passenger carriers and the utilization rates are 10 hrs/day, 13 hrs/day for AE (AMCI 10-402, 2004: 18).

Membership in the CRAF allows the carriers to participate in peacetime contract missions. These contracts add capacity, flexibility and efficiencies to the military airlift system but also provide large economic benefits to the carriers, which will be discussed in detail in the next section.

Economic Incentives/Impacts

The CRAF gives the government the necessary airlift to execute war plans and augment military lift in times of national crisis; in turn the government provides economic incentives for the airlines' commitment. Certain contracts to fly AMC missions are only available to CRAF participants, in addition to a certain amount of guaranteed business for both cargo and passenger carriers. In FY 2007 CRAF carriers provided $2.6B worth of airlift augmentation for the U.S. military (CLR, 2008: 22).

Mobility Value Points and Teaming

The CRAF system was created with benefits for the participants as well as the government. In order to manage the amount of airlift that the carriers are eligible for during peacetime, a points system was developed. Mobility Value (MV) points are awarded for each aircraft that is entered into the CRAF, along with certain bonuses for certain stage commitments. MV points are based on the range, payload, and productive utilization rate of each aircraft compared to a baseline aircraft, the Boeing B-747-100. The bonuses are added to the base value for aircraft committed to Stage I, AE qualified aircraft and for aircraft capable of carrying 75% of their maximum ACL more than 5000NM (CLR, 2008: 20).

The airlines use these points to compete for some airlift contracts, specifically the fixed and expansion buys; more points allow the carriers to compete for more work than they are normally eligible. This points system has led the CRAF participating airlines to form teams. The teaming arrangements allow carriers to pool and transfer their points, and bid on a larger number of contracts then would have been possible for each individual airline. The teaming arrangements are not controlled by AMC, and the contractual agreements between the airlines within a team are proprietary. The teaming arrangements have benefits for the larger CRAF participants, as well as the smaller carriers. The larger carriers provide the team a large pool of points with which to bid, but don't actually have to use their assets to fly the missions. They receive a percentage of the total payment from the government, with the remainder going to the carrier that actually flies the mission. The smaller carriers benefit by qualifying for more business than would be possible by competing as an independent carrier allowing them to fly over their MV point entitlement. The increased amount of business offsets the percentage of the revenue that is collected by the larger carriers.

There is some concern that the amount of government business that the smaller carriers have taken on since the terrorist attacks of 9/11 puts them at economic risk if the DoD contracts were to decrease. The main concern in the use of the CRAF is ensuring adequate participation and the proper ratio of government business versus civilian business. In 2005 the DoD accounted for 5 percent of total cargo usage industry-wide and 2 percent of total passenger revenue (CBO, 2007: 6). This small percentage should not adversely affect the industry if the DoD reduced its overall peacetime airlift requirements. However, a reduction could significantly affect specific carriers, like small charter companies.

Thirty-five to fifty-five percent of the equipment committed to the CRAF comes from the large integrators, FedEx and UPS, but they transport less than 4 percent of the cargo. The remainder of the DoD cargo requirements are carried by small charter companies. Since 2001 only 30 percent of the business for these small carriers has been DoD business (CBO, 2007: 6). This means that, presumably, the small charter carriers should be able to survive financially if the DoD business were to decrease significantly.

GSA City-Pair Contracts

A secondary incentive for CRAF participation is the General Services Administration (GSA) city-pair agreement. The GSA negotiates rates and conditions for government travel between specific city-pairs. The city-pair program was initiated in 1995, and is credited with bringing United Airlines and American Airlines back in to the CRAF. Following the first Gulf War in 1991, and the de-activation of CRAF assets, American and United stopped participating in the CRAF due to the large economic impact of activation. In order to compete in the city-pair program, United and American both re-committed to the CRAF (Lewis, 1998: 36). The GSA city-pair program ultimately provides a large amount of revenue for the participant's; in 2007 the program created $1.5B in revenue for the network carriers (CLR, 2008: 25).

Open Skies

The globalization of the airline industry creates a vulnerable economic environment for U.S. carriers participating in the CRAF. In 2010, full Stage III activation represented 32 percent of the airline industry's passenger capability, and over 35 percent of the available cargo capacity (AMC Form 312, 2010). If just 25 percent of the CRAF passenger capacity was activated, the potential impact in passenger markets could be staggering. During the CRAF activation in 1990-91 the passenger network carriers had a large commitment to their regular routes and were reluctant to rearrange their aircraft schedules due to a perceived possible loss of market share (Lewis, 1998: 35). This is compounded in the era of globalization. Removing specific long-haul aircraft from designated high-value, high-volume international routes due to CRAF activation could open these routes to foreign carriers. Following the CRAF activation in 1990-1991, cargo carriers lost market share to foreign competitors that signed long term contracts with large international shipping customers. This prevented/delayed FedEx and UPS from regaining that lost market share once the CRAF assets were returned to commercial service (GAO Report NSIAD 93-12, 1993: 8).

During the CRAF activation supporting Desert Storm in 1991, the international airline market was more closely regulated. Numerous international agreements were in place that were designed to protect the flag carriers of individual nations and restrict competition on certain routes, landing at specific airports and flying between specific locations. This type of regulation has gradually become less restrictive, starting in 1992 when the United States signed the first Open Skies Agreement (OSA) with the Netherlands (Micco and Serebrisky, 29: 2006). Over the past 18 years the U.S. has signed more than 50 OSA's, and while the specifics of each agreement is unique, the overall basis of these agreements seek the same goal. Open Skies Agreements are designed to provide:

> 1. *Free market competition*: No restrictions on number of designated airlines, capacity, frequencies, and types of aircraft
>
> 2. *Pricing determined by market forces*: a fare can only be disallowed if both signatory governments concur (double disapproval pricing) and only for certain, specified reasons intended to ensure competition.

> 3. *Fair and equal opportunity to compete*: all carriers of both countries may establish sales offices in the other country and can convert and remit earnings in hard currencies at any time.
>
> 4. *Optional seventh-freedom all-cargo rights*: Authority for an airline of one country to operate all-cargo services between the other country and a third country, through flights that are not linked to its homeland (Department of State Website, 2011).

These agreements are designed to further de-regulate the global airline industry, encourage competition and allow carriers to expand their foreign markets, and overall international market share. During peacetime, or times when the CRAF is not activated, these policies are an economic windfall for the large U.S. network carriers. Unfortunately, the same de-regulation rules could have an extremely negative affect on CRAF participants in the event of activation.

In FY2008 United Airlines and American Airlines both provided 26 Wide Body Equivalent (WBE) passenger aircraft for Stage II (AMC Form 312, 2008). Data gathered from the Bureau of Transportation Statistics (BTS) shows that on average American Airlines flies 10-12 flights between 3 major U.S. airports (Dallas, New York, and Chicago) and London, United Kingdom per day. These 3 city pairs represent almost half of American Airline’s Stage II commitment. If the CRAF were to be activated and American Airlines was forced to use all 26 CRAF aircraft, there would be significant economic losses on multiple high-value, high-volume international routes, in addition to the potential for future market share loss.

A second order effect of being unable to provide service on these routes from CRAF activation is the difficulty for U.S. carriers to regain the lost market share once the CRAF deactivated and assets are released for commercial operations. With Open Skies Agreements foreign carriers are now able to expand capacity for international travel on routes that the U.S. CRAF carriers cannot support when activated. Foreign carriers with excess capacity or ability to increase flight frequency can now provide service between the U.S. and their home nation, without restrictions. CRAF activation causes an immediate loss in revenue for U.S. carriers, but also causes loss of future market share if a foreign carrier is able to gain a strong foothold in a market. Regaining the lost market share after CRAF de-activation could be extremely problematic for the U.S. carriers, and cause further financial stress. For example, a U.S. carrier may be prevented from reducing fares in order to reclaim lost market share due to CRAF activation. Per the Open Skies Agreements, a fare reduction is subject to the double-disapproval rule. A fare reduction could be prevented by a foreign government, not allowing the U.S. carrier to regain market share loss due to a U.S. government policy decision.

Airlines have seen the potential economic impact of lost international market share, but also the economic opportunity that Open Skies agreements have presented. In order to fully realize this opportunity and to side-step some remaining regulatory obstacles, airlines began creating alliances, and global networks to offer services all over the world without incurring huge costs. These types of agreements are commonly called code-sharing, and each of the major U.S. airlines has some type of alliance and code-sharing agreement with major foreign carriers.

"The most common form of code-sharing allows a carrier relatively open access to its partner's capacity at a prorate determined by bilateral negotiations" (Whalen, 2007: 41). In addition to opening additional markets to U.S. and foreign carriers, code-sharing allows airlines to side-step cabotage regulations. Cabotage is the flying of domestic routes by foreign carriers, and is expressly prohibited by the U.S. and most foreign governments. Code-share agreements allow foreign carriers to offer their customers service on routes they would normally be excluded from, by selling a percentage of seats on a flight operated by a partner airline. This arrangement maximizes the number of passengers on certain routes while offsetting costs for the operating airline and creating additional revenue for the code-share airline. According to the Delta Airlines 2009 Annual report:

> International code-sharing agreements enable us to market and sell seats to an expanded number of international destinations. Under international code-sharing arrangements, we and a foreign carrier each publish our respective airline designator codes on a single flight operation, thereby allowing us and the foreign carrier to offer joint service with one aircraft, rather than operating separate services with two aircraft (DAL 2009 Annual Report SEC, 2010: 3).

While code-sharing is beneficial to the airlines, it is difficult to quantify its effects on the economic impact of CRAF activation. The alliances are negotiated individually by each airline, they are proprietary, have different incentives, ever changing price scales and varied support agreements. This is problematic when analyzing the economic impact of activation, and leaves AMC guessing how the levels of activation would affect each individual CRAF participant. In addition, airlines may be reluctant to fully use the code-sharing partners to fly their routes due to unfavorable branding issues. Customers may be reluctant to fly on certain foreign carriers, even if it is a sanctioned code-share flight. This branding dilemma may negate the positive effects code-sharing could bring during a CRAF activation.

The economic impact of the 1991 CRAF activation caused two airlines, American and United Airlines, to withdraw their assets from the CRAF program. Today with the larger impact of possible long lasting lost international market share, U.S. airlines could face a major economic crisis. The possibility of losing some of the major CRAF participants due to bankruptcy or lack of volunteerism is a real threat to the readiness of the Department of Defense. This threat directly translates into lost airlift capacity for future U.S. conflicts. CRAF provides large airlift capabilities to the DoD, and the loss of any one carrier would place undue strain on the remaining participants, creating a downward spiral in CRAF capability.

Defining Risk

The airline industry is a volatile market that is greatly impacted by even the smallest economic fluctuations. During the economic boom in the late 1990's the airline industry experienced record revenues, and maintained a 72 percent load factor. As the economy began to slow, the airline industry's net profit decreased 50 percent, from 5 billion dollars to 2.5 billion dollars in 1 year (Wensveen, 2007: 171). This dramatic decline in revenue and profit was caused by a minor economic slowdown; the effects of a major global incident such as the terrorist attacks of 9/11 were devastating to the industry. Following the events of 9/11 at least four major U.S network carriers (Delta, Northwest, United and US Airways) filed for bankruptcy protection, over 1000 airplanes across all carriers were parked as a cost saving measure and the industry profit margin fell to -8.7 percent (Wensveen, 2007: 171). The airlines are still dealing with the effects of these major events 10 years later, in addition to dealing with dramatic increases in fuel prices and a global recession.

The average dictionary definition of risk is the exposure to the chance of injury or loss (Dictionary.com Website, 2011: Online). Risk from a business perspective is more accurately defined in three parts; the chance of loss, the probability of that loss occurring and the amount of the loss (Collins and Ruefli, 1992: 1716). In a more abstract view, risk can be defined as the variability in a future position due to market changes and the uncertainty of future events (Artzner et al, 1999: 205). Artzner goes on to discuss acceptable and unacceptable levels of risk and explains that an unacceptable level of risk is a "position with a negative future net worth" (Artzner et al, 1999: 205). This definition applies well to the way the airlines must mitigate their individual risk levels.

The airlines assess risk on a daily basis; when evaluating weather conditions, traffic congestion, fee increases, global political situations, and natural disasters. The risk of adding a route, or leaving a market requires even greater analysis due to the immediate potential impact these decisions have on the financial stability of the airline. The airlines must do the same type of risk analysis with regards to the commitment of their fleets to the CRAF. The carriers must weigh the positive effects of participation (i.e. increased revenue from GSA city-pair fares) versus the negative impact of possible activation. According to Artzner's definition an airline would be considered at risk if the future position (i.e. CRAF activation) places the airline in a negative net worth position.

Airlines also measure risk in their ability to respond to world events and adjust their schedules, to maximize revenue. In the years 2000-2009, the airline industry underwent a transformation that decreased their flexibility. In 2009, there was a total of 7,132 commercial aircraft in service, a reduction of 323 aircraft from the previous year and a staggering 18.3 percent less than were in service in 2000 (U.S. DOT, 2010: 22-23). The downsizing of assets in the airline industry directly impacts the CRAF, but also limits the options of the carriers to absorb shocks to the system if the CRAF is activated. The airlines must now weigh their CRAF commitment with respect to smaller fleets, which leaves little flexibility in a very volatile market.

III. Methodology

Determining Risk

The level of financial risk for each airline varies by the route, country and region that are serviced. There are a number of possible factors that puts an airline at financial risk in certain areas; number of competitors, international regulations, price of fuel, etc. This research investigated whether CRAF participation affected international markets for the U.S. network carriers. Specifically, this study examined whether CRAF participation increased the network carrier's level of risk on international routes and it examined which international markets had the greatest exposure or highest level of risk for the network carriers.

The researcher defines risk for this study as a high use rate of a specific type of aircraft on any route, compared to the percentage of that airlines fleet that is committed to the CRAF. A high level of risk for an airline in a given market will increase exposure to greater financial risk for that airline. For example, if a carrier exclusively uses a Boeing 777 aircraft on the New York to London route, and 100% of their 777 fleet is committed to a CRAF stage, then that route would be considered at high risk, given a CRAF activation.

In order to analyze the risk level of the CRAF participating commercial carriers, airline market level data was collected. This data was collected from the Research and Innovative Technology Administration/Bureau of Transportation Statistics (RITA/BTS) website, http://www.bts.gov. The BTS compiles, analyzes, and publishes a comprehensive set of transportation statistics (BTS website, 2011). The data was collected from the BTS T-100 database. This database provides information reported by both U.S. and foreign air carriers, including carrier, origin, and destination for passengers, freight and mail when at least one point of service is in the United States. Financial, passenger and airline route coverage data from the RITA/BTS database was collected for the period of 1 May 2009 – 31 May 2010. This data was compiled to compare 94 international routes from 8 major airports in the United States to multiple destinations in the Atlantic and Asia/Pacific regions. This data was used to determine which were the most competitive routes, country pairs, and region with regards to market share, passenger demand and number of airlines that service the route.

Data was collected on routes between specific city pairs in the United States and two major regions of the world; the Atlantic and Asia/Pacific regions[2]. Over 51 percent of international travelers on U.S. flag carriers traveled to these two regions (U.S. DOT, 2010: 18). The dataset includes 30 airport/city-pairs. The U.S. airports were selected to include hubs for the major U.S. airlines that are also serviced by multiple foreign carriers[3]. The international airports selected were the capitols of the countries in the region, as well as centers of international business. Use of these airports guaranteed an acceptable sample of city-pairs as well as ensuring that the maximum number of U.S. and foreign-flag carriers would be included to create variability within the analysis.

Defining the Dependent Variable

The dependent variable (DV) for this study was the risk score. Risk is the probability of an event happening multiplied by the impact on the airline. The risk score was based on comparing the type of aircraft committed to each Stage of CRAF

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[2] See Appendix B for the list of U.S. and Foreign airports/city-pairs
[3] See Appendix A for the list of U.S. and Foreign air carriers

activation and the type of aircraft that was used to service each route, country and geographic region. This score predicted the critical areas for each specific carrier, and which airlines were most vulnerable to the economic factors associated with CRAF activation.

The formula has 3 variations, for risk at the route, country and regional level. The variables used to formulate the risk score were:

Figure 2: Risk Formulas

a = Aircraft type (i.e. Boeing 747, 757, 767, 777, Airbus 330)
i = Airline
AC = Aircraft
CRAF Stg = CRAF Stage I or II
Total Dep = Total Departures

The formulas used to calculate the risk score were:

Route Risk$_i$ = $\sum_a^n (\% \, AC_a \, Route_i * \% \, AC_a \, CRAF \, Stg_i * \% \, AC_a Total \, Dep_i)$

Country Risk$_i$ = $\sum_a^n (\% \, AC_a Country_i * \% \, AC_a \, CRAF \, Stg_i * \% \, AC_a Total \, Dep_i)$

Regional Risk$_i$ = $\sum_a^n (\% \, AC_a Region_i * \% \, AC_a \, CRAF \, Stg_i * \% \, AC_a Total \, Dep_i)$

Defining the Independent Variables

The independent variables in this model included the Passenger Market Share (MS), the Load Factor (LF), the Herfindahl-Hirschman Index (HHI) and the number of foreign competitors. Each of these variables was calculated at the route and country level of aggregation for each airline, *i*, in this study.

The Market Share is the percentage of passengers carried by an airline compared to all other competitors serving that market. Market Share shows the amount of business the airlines provide at each aggregation level, and can be used as a basis for the percentage of revenue an airline receives from the specific route and country. The level of risk is related to Market Share because it is an indicator of the amount of revenue that is generated by an airline servicing an area and is a function of the amount of revenue that could be lost were the carrier to pull their assets from that market. The researcher hypothesizes that a higher MS in an area, the higher level of risk if the CRAF is activated. High MS indicates high revenue as well as a substantial commitment to a specific market. This level of commitment places a carrier at risk of losing significant business, market share and revenue if the CRAF is activated.

Load Factor is the percentage of seats used compared to the number of seats available per flight. This variable demonstrates the amount of capacity that an airline has to absorb changes in schedules and aircraft availability. If an airline is working at a high LF then there is presumably no extra capacity to move into the market. As a point of reference, international LF's for U.S. carriers was 78.1 percent with close to a 3 percent forecasted increase in 2010 (U.S. DOT, 2010: 40). This increase is due to a predicted economic recovery and the reduced number of aircraft in the airlines' fleets.

A high Load Factor means that the airline is maximizing the usage of their assets, and if the CRAF were activated the airline would not have extra or spare capacity to move into that market. As such, a high Load Factor would increase risk if the CRAF were activated. Activation would probably cause the airline to lose all or some of the share of that market, thus the increased risk score. This increase is due to a predicted economic recovery and the reduced number of aircraft in the airlines' fleets.

The Herfindahl-Hirschman Index (HHI) is a measure of market concentration and is calculated by summing the squares of the market share of each competing firm in the market.

$$\mathbf{HHI} = \sum_i^n \boldsymbol{MS_i^2}$$

The HHI is calculated at the route, country and region levels and is an indicator of the amount of competition in a specific market. As HHI approaches 1.0, the market is considered to be more monopolistic; conversely a very low HHI represents a very competitive market. With regard to risk, a monopolistic market is more difficult to move in to for competitors. If CRAF were activated it would take competitors some time before they could begin service in a previously monopolistic market, and the chance they could absorb all of the demand, in the short-term, is highly unlikely. As such, it is expected that city-pair markets with a high HHI is related to lower risk scores.

The number of foreign competitors is the final variable that was hypothesized to affect an airlines level of risk. The number of foreign competitors is relevant when assessing risk, because the foreign airlines' assets will not be affected by CRAF activation. It is highly likely that other U.S. carriers would be affected similarly during CRAF activation, while the foreign competitors (obviously not subject to CRAF activation) could absorb passenger traffic that the U.S. airlines must abandon during the activation. Therefore, it is expected that a larger number of foreign competitors in a market is associated with a higher level of risk.

Levels of Risk

Risk was defined as a function of the percent an airline uses a certain type of aircraft and the level that the aircraft type is committed to CRAF Stage I and II. Airlines that commit a large number of a specific type of aircraft to the CRAF and use that same aircraft type to service a high value route, country or region, risk significant financial loss if the CRAF is activated. For example, multiple U.S. and foreign airlines serviced the New York to London route and the load factors were typically above 80 percent, during the period of this study. These indicators may predict that this route could have a high level of risk, if the aircraft used to service this route is also heavily committed to the CRAF. American Airlines (AA) was one of the airlines that serviced this route, they also happened to predominantly use Boeing 777s on this route; over 99.5 percent of the flights on this route used the 777. American Airlines also committed over 12 percent of their 777 fleet to CRAF Stage I and over 42 percent to Stage II. These factors should indicate a high risk score, and in fact the score for Stages I and II are 2.92 and 9.74, respectively. Delta Airlines (DL), which serviced the same route, but primarily used Boeing 767s (99.7 percent use rate) and committed less than 2 percent of these aircraft to Stage I and less than 5 percent to Stage II, had a significantly lower risk score. Delta's scores for this route for Stage I and II were .056 and .225, respectively.

Table 1: Example Risk Scores

Airline	**Depart**	**Arrive**	**Rte Risk CRAF 1**	**Rte Risk CRAF 2**	**Percent of 767 Fleet CRAF 1**	**Percent on Route 767**	**Percent of 767 Fleet CRAF 2**	**Percent of 777 Fleet CRAF 1**	**Percent on Route 777**	**Percent of 777 Fleet CRAF 2**
AA	JFK	LON	2.9213	9.7377	0.0136	0.0035	0.1506	0.1276	0.9952	0.4255
DL	JFK	LON	0.0563	0.2252	0.0109	0.9974	0.0439	0.0625	0	0.5

Based on an analysis of scores on predicted high and low risk routes, the researcher created a risk scale. The scale creates a simple way to discuss the level of risk that exists in each level of aggregation. The scale translates the risk scores into categories of Low, Moderate and High. To make the numbers manageable, the scores calculated for each level were multiplied by a factor of 1000. The tables below delineate the risk ranges for the route, country and regional scores as well as the average risk score for each airline in the models.

Table 2: Range of Risk Scores

	CRAF Activation Risk Score		
	Low	**Moderate**	**High**
Route	< 0.5	.5 > R ≤ 1.0	> 1.0
Country	< 15	15 > R ≤ 30	> 30
Region	< 15	15 > R ≤ 30	> 30

Table 3: Mean Risk Score by Airline

	Mean Risk Scores					
Airline	**Route Stage I**	**Route Stage II**	**Country Stage I**	**Country Stage II**	**Region Stage I**	**Region Stage II**
AA	0.2956	1.0192	9.0901	33.2859	21.9985	87.5529
DL	0.0183	0.1095	0.7316	3.6354	10.9035	84.0136
CO	0.0397	0.2184	1.3603	7.4815	13.4658	24.4981
UA	0.0610	0.4475	2.2785	19.1506	2.6579	18.7804

Type of Analysis

The primary method of analyzing the data in this study was done with an Analysis of Variance (ANOVA) Model. An ANOVA model is "used to uncover the main and interaction effects of categorical independent variables (called "factors") on an interval dependent variable" (Garson, 2011: 2). The 'main effect' is a direct effect that an independent variable has on the dependent variable, while an 'interaction effect' is the combined effect of multiple independent variables on the dependent variable. For the purpose of this study, the Risk score was the dependent variable and the independent variables included Passenger Marketshare, Load Factor, Herfindahl-Hirschman Index (HHI) and the number of foreign competitors.

The ANOVA model uses the F-test of difference of group means as the primary statistic. The F-test determines if the "means of the groups formed by values of the independent variable (or combinations of values for multiple independent variables) are different enough not to have occurred by chance" (Garson, 2011: 2). If a relationship between the independent and dependent variables is shown then multiple comparisons can be analyzed. Multiple analyses are done to determine which dependent variable has the most impact on the independent variable, and the level of significance of the relationship.

There are a number of required conditions for a valid ANOVA F-test. The samples are randomly selected, the sampled populations are approximately normally distributed and the population variances are equal (McClave, Benson and Sincich, 2011: 460). The benefits of an ANOVA model is that the results can be easily tabulated and summarized and that it demonstrates robustness in samples that deviate slightly from a normal distribution. Moderate departures from normality do not have much effect on the significance level of the ANOVA F-test or on confidence coefficients (McClave, Benson and Sincich, 2011: 463). McClave, Benson and Sincich acknowledge that while ANOVA is a very robust statistical analysis method it is weakened if the population variances are not equal. Ensuring the sample sizes are equal can mitigate this weakness, and in turn minimize the negative effect on the reliability measures of the test.

IV. Data Analysis

The data collected for use in this study's model is an aggregation, over a 12-month period, of the basic data from the BTS database. Using Microsoft Excel spreadsheets and calculations, the researcher expanded the basic data into the variables that were used in analyzing potential risk factors and predictors. The variables were first calculated at the individual city-pair level and then aggregated to the country level, and ultimately the region level for each U.S. airline in the study. In addition to the BTS data, CRAF participation data was gathered from the AMC CRAF Fleet Branch, HQ AMC/A34BC. The participation percentage of each aircraft type was calculated using the AMC participation numbers from the AMC Form 312 and the number of aircraft in each airline's fleet from their SEC-10 Annual Reports[4].

Table 4: Descriptive Statistics Summary[5]

Variable	Mean	SD	Min	Max	N
Rte Risk Stage I	0.1087	0.3789	0	2.9213	122
Rte Risk Stage II	0.4676	1.2776	0	9.7378	122
Country Risk Stage I	3.5267	7.0233	0	28.8199	122
Country Risk Stage II	16.6100	24.0459	0	97.5748	122
Route MS	0.5196	0.3701	0.0006	1	122
Country MS	0.1675	0.1187	0.0011	0.9675	122
Route HHI	0.6198	0.2961	0.1303	1	122
Country HHI	0.2762	0.1195	0.1241	0.9371	122
Route LF	0.8205	0.0731	0.3494	0.9959	122
Country LF	0.8176	0.0551	0.3494	0.8920	122
Route Foreign Comp	1.2131	1.2414	0	5	122
Country Foreign Comp	3.7869	2.0499	1	7	122

4 See Appendix C for airline CRAF commitments and Appendix D for airline fleet data

5 See Appendix F for the summary of descriptive statistics for each variable in the risk score model, separated by airline.

Assumptions/Limitations

Within the airline industry there is a large amount of proprietary data. This research's data set was limited to what the U.S. government publicly collected, and did not include any factors that individual airlines used to overcome the economic limitations of CRAF participation. Since the airlines' actual business models were not known, the author assumed that the types of aircraft used to service specific routes and countries were the only option available, and that some form of risk mitigation had been accomplished by each airline. This assumption keeps the risk calculation and prediction model simple; to give a general sense if an airline is at risk in certain areas.

Every CRAF participating airline in this study services multiple international locations. Not all routes are deemed competitive and some routes are limited by international agreements and airport traffic limitations that regulate the level of competition. This study concentrated on major city-pair routes that are competitive between multiple U.S. and international carriers[6]. The research was limited to 8 major U.S. airports, and the capitols and business centers of the foreign countries. This self-imposed restriction kept the data analysis manageable, while providing a broad enough scope to predict risk for the CRAF participants.

During the timeframe that this dataset encompasses, Northwest Airlines merged with Delta Airlines. This limited the amount, type, and quality of data that was collected on Northwest. The spurious data points skewed the overall data analysis when Northwest was included in any of the models. Due to these skewed

[6] Appendix E lists all of the routes used in the model by city-pair.

results, and the relatively small amount of Northwest data points, Northwest was selectively removed from the analysis at all levels of aggregation.

CRAF activation can be tailored and real world activation does not necessarily fit the book definition of full activation. For the purpose of this study, activation will be considered to require and use the full capability of each stage.

Finally, international aviation agreements are constantly being negotiated. Any change to these arrangements could affect future economic data. In this study the data will be analyzed under the constraints of the laws and agreements at the time the data was collected.

Analysis Tools

Once the raw data was expanded into the required variables within Excel, the data was loaded into PASW Statistics Analysis Software Version 17.0, commonly referred to as SPSS, to accomplish the ANOVA analysis. The data was separated into 3 distinct datasets; the route, country and regional level. Each dataset was analyzed using the Univariate General Linear Model (GLM) analysis tool. The GLM provides analysis on the interaction of selected variables to test for relationships and statistical significance. SPSS provides basic descriptive statistics, a Test of Between-Subjects effects, Parameter estimates that show the interaction each independent variable (IV) has on the dependent variable (DV), and Pairwise Comparisons between defined fixed factors.

The Test of Between-Subjects provides the same data as a basic regression, with F-test values and the corresponding significance. This allows the researcher to determine which IVs affect the DV, and the level of statistical significance that can be applied to this interaction. The Parameter Estimates analysis produces *b coefficients* that predict the positive/negative effect of the IV on the DV, and the magnitude of that effect. Finally, the Pairwise Comparison looks at the mean difference of the DV associated with a fixed factor. In this study, this analysis compared the different airlines' risk scores to each other to determine if there was a statistically significant difference.

V. Results

Overall, the data showed significant results in the route and country models, as shown in Table 5. The regional aggregation showed similar relationships to the route and country models, but due to the small sample sizes, there was little significance in the region model, therefore the only results discussed here are at the route- and country-levels. The relationship of the independent variables to the dependent risk variable matched the hypotheses in all cases except the Load Factor variable. While the Load Factor variable in the Stage I route level model matched the hypothesis that a higher LF would increase the risk score, at a 90% significance level, the other models showed the opposite relationship, although these were either not statistically significant or showed only a weak relationship. The LF results in the Stage I Route model could be an anomaly since they were so different from the other models; the positive relationship is relatively small in the Stage I Route model, compared to the greater negative relationships in the Stage II Route model and the Stage I/II Country models. The three models that showed a strong negative correlation between risk score and LF had no statistical significance in the models. This possibly shows that there could be an interaction effect between LF and another variable that was not defined in this study or more likely that LF has no impact on the risk score model.

The analysis also showed a significant difference between the airlines in their levels of risk. One airline in particular was significantly different then the other 3 carriers in the study. This is notable because it shows there is an obvious difference in that carrier's business model, either in the way it handles CRAF commitments or in its overall risk mitigation process. The chart below shows the statistical results for both the Stage I and II models at the route and country aggregation.

Table 5: ANOVA Results[1]

Variables	CRAF Stage I Route Risk	CRAF Stage I Country Risk	CRAF Stage II Route Risk	CRAF Stage II Country Risk
Intercept	0.345	8.0342	1.1452	24.1832
	(0.791)	(-1.0276)	(-0.7792)	(0.8738)
Market Share	0.425 **	8.9293 +	1.5939 **	36.4834 *
	(2.980)	(-1.6825)	(-3.3173)	(1.9421)
HHI	-0.17	-8.0152	-0.7826	-36.2042 *
	(-.925)	(-1.5674)	(-1.2651)	(-2.0002)
Load Factor	0.734 +	-11.3900	-2.3941 +	-34.0234
	(-1.692)	(-1.2551)	(-1.636)	(-1.0593)
Foreign Comp	0.09 *	0.8965 **	0.3124 **	3.4344 **
	(2.331)	(-2.4647)	(-2.4062)	(2.6674)
AA	.863 **	10.7911 **	2.8726 **	35.2082 **
	(3.905)	(-2.695)	(-3.8526)	(2.4841)
DL	0.107	0.8723	0.5546	6.9508
	(.485)	(-0.2627)	(-0.7465)	(0.5914)
UA	0.084	2.1859	0.5524	16.9271
	(.429)	(-0.6706)	(-0.8401)	(1.4673)
Atlantic Reg	0.058	1.1756	0.2819	7.0253
	(.304)	(-0.408)	(-0.4402)	(0.6890)
AA x Atl Reg	-0.709 **	-8.947 *	-2.4152 **	-29.3606 +
	(-2.950)	(-2.0104)	(-2.9807)	(-1.8639)
DL x Atl Reg	-0.123	-2.0518	-0.6993	-13.7789
	(-.509)	(-0.5378)	(-0.8546)	(-1.0204)
UA x Atl Reg	-0.054	-3.5080	-0.3574	-17.7298
	(-.242)	(-0.8876)	(-0.4755)	(-1.2674)
N	122	51	122	51
R^2	0.291	0.389	0.291	0.419
Adj R^2	0.22	0.216	0.220	0.255
F	4.1074 ***	2.2539 *	4.099 ***	2.556 **
df	121	50	121	50

1: t-statistics are in parentheses, *** p < 0.001 ** p < 0.01 * p < 0.05 + p < 0.1

Route Risk

At the route level, for both Stage I and II activation, the most important independent variables in determining a risk score were the airline's market share of the route, the number of foreign competitors on the route and the airline operating on the route. These variables were significant at the 95% level and have a positive *b coefficient*. In the case of market share this positive relationship shows that for every 1 percent increase in the firm's market share there is a corresponding .425 unit increase in risk score for Stage I, and 1.59 unit increase at Stage II. The stage unit increase is notable, because Stage II risk is nearly 4 times greater than Stage I. This means that during Stage II activation the route level risk increases very quickly compared to Stage I, as the airline's market share increases on any international route. This relationship matched the proposed hypothesis, that higher market share would increase the risk score of the carriers. The positive *b coefficient* for the number of the foreign competitors variable also shows that an increase in competitors correlates to an increased risk score, in line with the researcher's hypothesis. As expected there was a greater effect during Stage II activation, with a .312 unit increase in the risk score for every additional foreign competitor, due to the greater number of assets that the U.S. carriers would lose to Stage II operations. At the route level, the Load Factor variable showed small significance while HHI was not statistically significant in predicting the risk score at the route level.

Country Risk

The country level results showed similar relationships between the variables, but the differences were notable. The market share and the number of foreign competitors remained significant in the country risk model, with the risk score increasing as the variables increased. Interestingly, at the country level the HHI variable became significant in predicting risk. The researcher believes this is because at the country level aggregation there were more data points to examine. Higher levels of competition were more easily observed at the country level versus at the route level. There were some routes in the study that were only serviced by one airline, but each country in the study was serviced by multiple airlines. The increased number of competitors at the country level allowed for more complete results, thus the increase in significance of the HHI variable between the route and country levels. The fact that HHI becomes significant at the country level is important to understand because although a route may show a low risk score, the loss of that route due to CRAF activation could have a great impact on the ability of the airline to service that country.

United, American and Continental airlines all operated routes that had a low risk score within a country that had a moderate or high risk score during CRAF Stage II activations. United Airlines' Los Angeles (LAX) to Tokyo, Japan (NRT) route scored a low .236, while the country risk for United in Japan was at the top end of the moderate risk range at 28.49. American Airlines flew multiple routes to England, and the country risk score was extremely high at 97.57. Although, England was a high-risk country for American, the Chicago (ORD) to Manchester, England (MAN) route was a low risk route with a score of .028. Continental flew two routes to Germany from Newark (EWR). The route to Frankfurt (FRA) was in the moderate range during Stage II activation, while the flight to Munich (MUC) had a low risk score. At the country level, Germany fell in the moderate risk category for Continental with a score of 16.51. These variations in risk score between the route and country level demonstrate that a single data point (i.e. route risk for a specific airline and city pair) does not provide the full picture of risk for that airline. The results at each level of aggregation must be considered when analyzing the risk of CRAF activation.

Table 6: Sample of Route and Country Risk Analysis

Airline	Depart	Arrive	Route Risk CRAF 1	Route Risk CRAF 2	Country Risk CRAF 1	Country Risk CRAF 2
AA	ORD	MAN	0.0026	0.0286	28.8198	97.5748
CO	EWR	FRA	0.1085	0.5969	3.0173	16.5955
CO	EWR	MUC	0.0038	0.0213	3.0173	16.5955
UA	LAX	NRT	0.0333	0.2363	4.7173	28.4942

Route Risk Score Ranges - Low: 0 - .5; Moderate: .5 >≤ 1.0; High: > 1.0
Country Risk Score Ranges – Low: 0 – 15; Moderate: 15 >≤ 30; High: > 30

Airline Risk

Each of the airlines assume some form of risk when they commit their assets to the CRAF. It is assumed that each airline does their own risk mitigation that fits within their business model. This study compared the risk scores of the airlines to determine if there were differences between each airline.

Table 7: Airline Risk Score Pairwise Comparison

		CRAF Stage I		CRAF Stage II	
		Route Risk	Country Risk	Route Risk	Country Risk
Airline		*Mean Difference*		*Mean Difference*	
American Airlines (AA)	Delta Airlines (DL)	.464*	6.471*	1.460*	20.466*
	United Airlines (UA)	.452*	5.886*	1.291*	12.466
	Continental Airlines (CO)	.509*	6.318*	1.665*	20.528*
DL	AA	-.464*	-6.471*	-1.460*	-20.466*
	UA	-.011	-.586	-.169	-8.001
	CO	.045	-.154	.205	.061
UA	AA	-.452*	-5.886*	-1.291*	-12.466
	DL	.011	.586	.169	8.001
	CO	.057	.432	.374	8.062
CO	AA	-.509*	-6.318*	-1.665*	-20.528*
	DL	-.045	.154	-.205	-.061
	UA	-.057	-.432	-.374	-8.062

*. The mean difference is significant at the .05 level.

The chart above clearly shows that American Airlines was significantly different than the other carriers, while the remaining carriers were similar in their risk scores. Further analysis of the data explains that the reason American Airlines risk scores were so different from the other carriers was because of the assets they have committed to specific CRAF stages. American Airlines committed slightly less than 50 percent of their 777 fleet and just less than 20 percent of their 767 fleet to Stage II. These aircraft comprise the majority of international flight operations for American Airlines. 38% of departures to the Atlantic region were 767s, and 42% were 777s. A high risk score was predictable with the large dependence on these aircraft in the Atlantic market, in addition to the large percentage of these aircraft committed to Stage I and II operations. In contrast, the other U.S. airlines do not commit a large percentage of their aircraft to Stage I and II, producing a statistically significantly lower risk score at each aggregation level.

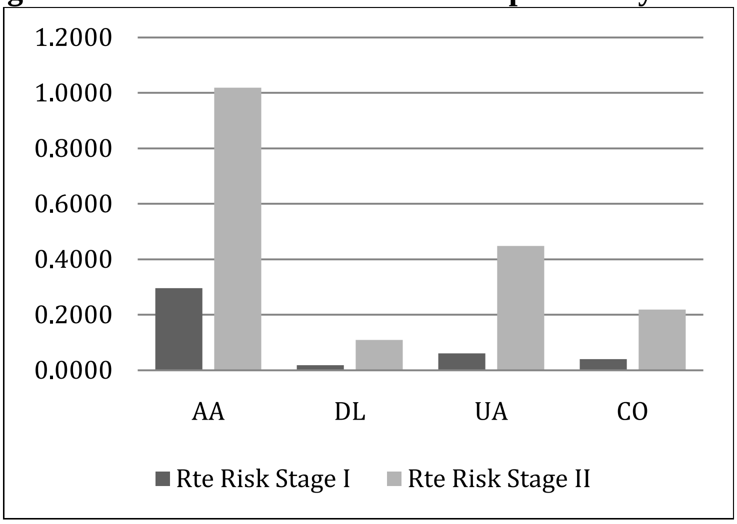
Table 8: CRAF Commitment Comparison

Airline	Aircraft Type	Stage I	% of Fleet	Stage II	% of Fleet
AA	767	1	1.4%	11	15.1%
AA	777	6	12.8%	20	42.5%
CO	767	2	7.7%	11	42.3%
CO	777	0	0%	0	0%
DL	767	1	1.1%	4	4.4%
DL	777	1	6.3%	8	50%
UA	767	0	0%	0	0%
UA	777	1	1.9%	12	23.1%

The significance in the mean risk score differences decreased slightly between American Airlines and United Airlines at the Country level for Stage II activation. This was due to United's increased risk score, which was influenced by the fact that almost 50 percent of United's 747 fleet was committed to Stage II. The 747 is almost exclusively used for international flights and comprises over 30 percent of the aircraft

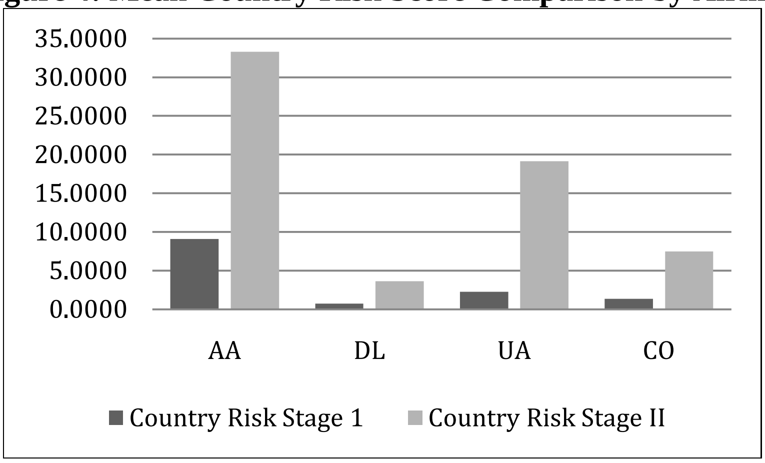
United Airlines used to service the Asia/Pacific region. Out of the 4 airlines included in the model, United was the only airline that contributed 747s to the CRAF. This increased dependence on a specific aircraft type, coupled with a large CRAF commitment of the same aircraft increased the risk score, similar to American Airline's risk associated with the 777 in the Atlantic region.

Figure 3: Mean Route Risk Score Comparison by Airline



Route Risk Score Ranges - Low: 0 - .5; Moderate: .5 >≤ 1.0; High: > 1.0

Figure 4: Mean Country Risk Score Comparison by Airline



Country Risk Score Ranges – Low: 0 – 15; Moderate: 15 >≤ 30; High: > 30

The data showed that there was a significant difference between American Airlines and the other three U.S. carriers in this study, at both the route and country level.

VI. Conclusion and Discussion

CRAF remains a vital aspect of U.S. national security and provides needed capability to ensure the DoD can effectively project power around the globe. The importance of the CRAF fleet to U.S. military operations and the volatility of the airline industry demands that TRANSCOM have a full understanding of how CRAF activation could affect military readiness.

This research looked at three basic questions: 1) Which U.S. carriers have the highest level of risk during activation? 2) Which international routes are the most at risk? 3) What are the factors/predictors of an airline/route with a high level of risk? The analysis showed that American Airlines had significantly higher risk scores in all of the models, as well as showing a significant increase of United Airlines' risk score in the Asia/Pacific region. In addition, routes that had high levels of foreign competition or the airline had a large market share on that route lead to higher risk scores. These strategically important routes would be at significant risk during CRAF activation, and U.S. airlines may be economically crippled if they were unable to service these routes, or completely lose future access to the routes.

The model used in this study shows that there are strategic routes, countries and regions in the world that should be considered at risk for some of the network carriers. This is specifically related to the dependence on specific aircraft types for high revenue routes when those same aircraft are also highly committed to the CRAF. This was notable in the significant difference in risk scores between American Airlines compared to the other 3 airlines throughout the study. American Airlines commits a large percentage of their Boeing 777 aircraft to the CRAF, while also using it on a majority of strategic routes. The impact of over committing a high demand asset to the CRAF was supported with United Airlines' risk score increasing in the Asia/Pacific region where Boeing 747s are widely used. There is a general trend by network carriers toward a stronger presence in international markets. As market share grows in these markets and competition from foreign air carriers increases, risk due to CRAF activation increases. This could adversely affect CRAF participation. Thus, DoD should consider this when formulating CRAF policy, particularly policy that affects incentives.

This study was intentionally limited in scope, future research could expand on these results by including additional regions, and countries or include some of the smaller U.S. international airports to increase the airline and route sample size. The business model of each airline is highly proprietary and as such it was difficult to devise variables that accounted for individual decision-making processes within the airlines. One aspect of the airlines' business models that could be studied in the future is the use code-sharing relationships during activation. Use of code-share partners presents interesting challenges for the network carriers because airlines may be reluctant to fully use the code-sharing partners to fly their routes due to unfavorable branding issues. Customers may also be reluctant to fly on certain foreign carriers, even if it is a sanctioned code-share flight. This branding dilemma may negate the positive effects code-sharing could bring during a CRAF activation.

One of the assumptions in this study was that activation was all or nothing. In all likelihood, this is not how TRANSCOM would use the CRAF if activation were required. Due to the flexibility of CRAF activation it is important to realize which airlines could be stressed if certain aircraft were activated and how long that activation lasted; this will help to possibly tailor the activation for maximum effectiveness but also minimum invasiveness to the airlines' daily schedules. This study shows that there were airlines with high levels of CRAF committed aircraft on strategic routes. This should be acknowledged by TRANSCOM and is definitely an area worth further analysis.

The U.S. military must be aware of how its decisions will affect the airlines, and in turn the overall health of the CRAF fleet. The economic impact of CRAF activation is important to the airlines and the Department of Defense. This study evaluated the implications of activating the CRAF and allows for informed decisions on the different levels of activation. Using this study, leaders will better understand the far-reaching impact of CRAF activation on the airlines and ultimately the Department of Defense's capabilities.

Appendix A: Airline Codes

United States:
AA = American Airlines; Airline Number = 1
CO = Continental Airlines; Airline Number = 3
DL = Delta Airlines; Airline Number = 2
NW = Northwest Airlines[7]; Airline Number = 5
UA = United Airlines; Airline Number = 4

Foreign:
EI = Aer Lingus
AB = Air Berlin
CA = Air China
UX = Air Europa
AF = Air France
AI = Air India
NZ = Air New Zealand
TN = Air Tahiti
AZ = Alitalia Airlines
NH = All Nippon Airways
OZ = Asiana Airlines
BA = British Airways
CX = Cathay Pacific Airways
MU = China Eastern Air
A0 = Elysair
IB = Iberia Airlines
JL = Japan Airlines
KL = KLM Royal Dutch Airlines
KE = Korean Airlines
KU = Kuwaiti Airlines
LH = Lufthansa German Airlines
MH = Malaysian Airlines
GJ = Mexicargo
0OQ = Open Skies
PK = Pakistan International Airlines
QF = Qantas Airways
SK = Scandinavian Airlines
SQ = Singapore Airlines
LX = Swiss International Airlines
TP = TAP Portuguese Airlines
BRQ = Thomas Cook Airlines
VS = Virgin Atlantic Airways
SE2 = XL Airways France

[7] Northwest Airlines data was collected for a portion of the 12-month time frame in the study. During this time Northwest merged with Delta Airlines. As of 31 Jan 2010 all Northwest Airlines flights were coded as Delta Airlines flights (Delta website, Online, 2011).

Appendix B: Airline/Airport Codes

Airport Codes

United States:
ATL – Atlanta International Airport
DFW – Dallas/Forth Worth International Airport
EWR – Newark/Liberty International Airport
IAD – Dulles International Airport
JFK – John F. Kennedy International Airport
LAX – Los Angles International Airport
ORD – Chicago O'Hare International Airport
SFO – San Francisco International Airport

Foreign:
ARN – Stockholm, Sweden International Airport
BCN – Barcelona, Spain International Airport
BRU – Brussels, Belgium International Airport
CPH – Copenhagen, Denmark International Airport
DUB – Dublin, Ireland International Airport
FRA – Frankfurt, Germany International Airport
HKG – Hong Kong International Airport
ICN – Seoul, South Korea International Airport
LIS – Lisbon, Portugal International Airport
LON – Aggregation of Heathrow/Gatwick, England International Airport
MAD – Madrid, Spain International Airport
MAN – Manchester, England International Airport
MUC – Munich, Germany International Airport
MXP – Milan, Italy International Airport
NRT – Tokyo/Narita, Japan International Airport
OSL – Oslo, Norway International Airport
PAR – Aggregation of Charles deGaulle and Orly Paris, France International Airport
PEK – Beijing, China International Airport
PVG – Shanghai, China International Airport
ROM – Leonardo Da Vinci Rome, Italy International Airport
SYD – Sydney, Australia International Airport
ZRH – Zurich, Switzerland International Airport

Appendix C: CRAF Commitments

		Stage 1	Stage 2	Stage 3
CO	757-200ER	**0**	**0**	**41**
CO	767-200ER	**1**	**4**	**10**
CO	767-300ER	**0**	**0**	**0**
CO	767-400ER	**1**	**7**	**16**
CO	777-200ER	**0**	**0**	**20**
CO	777-200A	**0**	**0**	**0**
CO	777-200B	**0**	**0**	**0**
CO	747-200	**0**	**0**	**0**
CO	747-400	**0**	**0**	**0**
CO	330-200	**0**	**0**	**0**
CO	330-300	**0**	**0**	**0**

		Stage 1	Stage 2	Stage 3
AA	757-200ER	**0**	**0**	**20**
AA	767-200ER	**0**	**0**	**0**
AA	767-300ER	**1**	**11**	**58**
AA	767-400ER	**0**	**0**	**0**
AA	777-200ER	**6**	**20**	**47**
AA	777-200A	**0**	**0**	**0**
AA	777-200B	**0**	**0**	**0**
AA	747-200	**0**	**0**	**0**
AA	747-400	**0**	**0**	**0**
AA	330-200	**0**	**0**	**0**
AA	330-300	**0**	**0**	**0**

		Stage 1	Stage 2	Stage 3
NW	757-200ER	**0**	**0**	**0**
NW	767-200ER	**0**	**0**	**0**
NW	767-300ER	**0**	**0**	**0**
NW	767-400ER	**0**	**0**	**0**
NW	777-200ER	**0**	**0**	**0**
NW	777-200A	**0**	**0**	**0**
NW	777-200B	**0**	**0**	**0**
NW	747-200	**2**	**2**	**2**
NW	747-400	**4**	**9**	**16**
NW	330-200	**0**	**0**	**11**
NW	330-300	**3**	**8**	**21**

		Stage 1	Stage 2	Stage 3
DL	757-200ER	**0**	**0**	**0**
DL	767-200ER	**0**	**0**	**0**
DL	767-300ER	**0**	**0**	**56**
DL	767-400ER	**1**	**4**	**21**
DL	777-200ER	**1**	**8**	**8**
DL	777-200A	**0**	**0**	**0**
DL	777-200B	**0**	**0**	**0**
DL	747-200	**0**	**0**	**0**
DL	747-400	**0**	**0**	**0**
DL	330-200	**0**	**0**	**0**
DL	330-300	**0**	**0**	**0**

		Stage 1	Stage 2	Stage 3
UA	757-200ER	**0**	**0**	**0**
UA	767-200ER	**0**	**0**	**0**
UA	767-300ER	**0**	**0**	**21**
UA	767-400ER	**0**	**0**	**0**
UA	777-200ER	**0**	**0**	**0**
UA	777-200A	**1**	**1**	**13**
UA	777-200B	**0**	**11**	**33**
UA	747-200	**0**	**0**	**0**
UA	747-400	**2**	**11**	**25**
UA	330-200	**0**	**0**	**0**
UA	330-300	**0**	**0**	**0**

Appendix D: Airline Fleet Data

Airline	A/C	# in fleet	% of fleet
AA	737	77	18.60%
AA	MD-80	93	22.46%
AA	757	124	29.95%
AA	767	73	17.63%
AA	777	47	11.35%
AA	747	0	0.00%
AA	A330	0	0.00%
	Total	414	
CO	737	232	67.84%
CO	757	62	18.13%
CO	767	26	7.60%
CO	777	22	6.43%
CO	747	0	0.00%
CO	A330	0	0.00%
	Total	342	
DL	737	81	12.02%
DL	A319	57	8.46%
DL	A320	69	10.24%
DL	MD-88	116	17.21%
DL	MD-90	16	2.37%
DL	757	181	26.85%
DL	767	91	13.50%
DL	777	16	2.37%
DL	747	16	2.37%
DL	A330	31	4.60%
	Total	674	
NW	A319	57	24.05%
NW	A320	69	29.11%
NW	757	61	25.74%
NW	767	0	0.00%
NW	777	0	0.00%
NW	747	18	7.59%
NW	A330	32	13.50%
	Total	237	
UA	A319	55	15.28%
UA	A320	97	26.94%
UA	757	96	26.67%
UA	767	35	9.72%
UA	777	52	14.44%
UA	747	25	6.94%
UA	A330	0	0.00%
	Total	360	

Appendix E: Route City-Pairs

Departure City	Atlantic Destinations	Asia/Pacific Destinations
New York (JFK)	Stockholm (ARN) Barcelona (BCN) Brussels (BRU) Copenhagen (CPH) Dublin (DUB) London (LHR, LGW) Frankfurt (FRA) Madrid (MAD) Manchester (MAN) Munich (MUC) Milan (MXP) Paris (ORY, CHG) Rome (ROM) Zurich (ZRH)	Tokyo (NRT)
Newark (EWR)	Stockholm (ARN) Barcelona (BCN) Brussels (BRU) Copenhagen (CPH) Dublin (DUB) Frankfurt (FRA) Lisbon (LIS) London (LHR, LGW) Madrid (MAD) Manchester (MAN) Munich (MUC) Milan (MXP) Oslo (OSL) Paris (ORY, CHG) Rome (ROM) Zurich (ZRH)	Hong Kong (HKG) Tokyo (NRT) Beijing (PEK) Shanghai (PVG)
Washington DC (IAD)	Brussels (BRU) Frankfurt (FRA) London (LHR, LGW) Munich (MUC) Paris (ORY, CHG) Rome (ROM) Zurich (ZRH)	Tokyo (NRT) Beijing (PEK)
Atlanta (ATL)	Stockholm (ARN) Barcelona (BCN) Brussels (BRU) Copenhagen (CPH) Dublin (DUB) Frankfurt (FRA)	Seoul (ICN) Tokyo (NRT) Shanghai (PVG)

	London (LHR, LGW) Madrid (MAD) Manchester (MAN) Munich (MUC) Milan (MXP) Paris (ORY, CHG) Rome (ROM) Zurich (ZRH)	
Dallas-Fort Worth (DFW)	Dublin (DUB) Frankfurt (FRA) London (LHR, LGW) Madrid (MAD) Milan (MXP) Paris (ORY, CHG)	Tokyo (NRT)
Chicago (ORD)	Brussels (BRU) Copenhagen (CPH) Dublin (DUB) Frankfurt (FRA) London (LHR, LGW) Manchester (MAN) Munich (MUC) Paris (ORY, CHG) Rome (ROM)	Hong Kong (HKG) Seoul (ICN) Tokyo (NRT) Beijing (PEK) Shanghai (PVG)
Los Angeles (LAX)	London (LHR, LGW) Paris (ORY, CHG)	Tokyo (NRT) Sydney (SYD)
San Francisco (SFO)	Frankfurt (FRA) London (LHR, LGW)	Hong Kong (HKG) Seoul (ICN) Tokyo (NRT) Beijing (PEK) Shanghai (PVG) Sydney (SYD)

Appendix F: Descriptive Statistics Summaries

American Airlines	**Rte Risk Stage I**	**Rte Risk Stage II**	**Country Risk Stage 1**	**Country Risk Stage II**	**Regional Risk Stage I**	**Regional Risk Stage 2**	**Route MS**	**Country MS**	**Regional MS**	**Route HHI**	**Country HHI**	**Regional HHI**	**Route LF**	**Country LF**	**Regional LF**	**Route Foreign Comp**	**Country Foreign Comp**	**Regional Foreign Comp**
Mean	0.2956	1.0192	9.0901	33.2859	21.9985	87.5529	0.4026	0.1467	0.1156	0.5470	0.2408	0.0952	0.8176	0.8055	0.8063	1.3636	4.1818	23.3939
Standard Error	0.1208	0.4004	2.0227	6.5040	0.2926	0.7962	0.0625	0.0112	0.0043	0.0489	0.0147	0.0011	0.0141	0.0054	0.0015	0.2211	0.3548	1.2286
Median	0.0132	0.1310	1.0807	11.8882	21.1395	89.8900	0.3098	0.1646	0.1283	0.5007	0.2056	0.0919	0.8057	0.8008	0.8108	1.0000	4.0000	27.0000
Mode	0.0000	0.0000	28.8199	97.5748	21.1395	89.8900	1.0000	0.1797	0.1283	1.0000	0.2014	0.0919	#N/A	0.7904	0.8108	0.0000	6.0000	27.0000
Std Dev	0.6939	2.3002	11.6198	37.3626	1.6811	4.5741	0.3588	0.0641	0.0249	0.2808	0.0843	0.0066	0.0809	0.0308	0.0088	1.2703	2.0380	7.0575
Sample Variance	0.4816	5.2911	135.018	1395.9631	2.8262	20.9224	0.1287	0.0041	0.0006	0.0788	0.0071	0.0000	0.0065	0.0009	0.0001	1.6136	4.1534	49.8087
Kurtosis	9.5535	9.6316	-1.0839	-1.0007	0.1872	0.1872	-0.897	2.5819	0.1872	-0.963	-1.339	0.1872	1.3962	0.0775	0.1872	-0.420	-1.4886	0.1872
Skewness	3.1039	3.1166	0.8775	0.8961	1.4763	-1.4763	0.6733	0.9660	-1.4763	0.6173	0.2299	1.4763	-0.0429	0.9479	-1.4763	0.6180	0.1152	-1.4763
Range	2.9213	9.7378	28.6853	96.0942	4.0494	11.0180	0.9994	0.2852	0.0601	0.8697	0.2465	0.0158	0.4065	0.1052	0.0211	4.0000	6.0000	17.0000
Min	0.0000	0.0000	0.1346	1.4807	21.1395	78.8720	0.0006	0.0434	0.0682	0.1303	0.1241	0.0919	0.5894	0.7677	0.7896	0.0000	1.0000	10.0000
Max	2.9213	9.7378	28.8199	97.5748	25.1889	89.8900	1.0000	0.3287	0.1283	1.0000	0.3706	0.1077	0.9959	0.8729	0.8108	4.0000	7.0000	27.0000
Sum	9.7548	33.632	299.973	1098.4363	725.949	2889.244	13.284	4.8398	3.8145	18.049	7.9480	3.1422	26.981	26.581	26.607	45.000	138.000	772.000
Count	33.000	33.000	33.0000	33	33.0000	33.0000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.0000	33.0000
Confidence Level (95.0%)	0.2461	0.8156	4.1202	13.2482	0.5961	1.6219	0.1272	0.0227	0.0088	0.0996	0.0299	0.0023	0.0287	0.0109	0.0031	0.4504	0.7226	2.5025

Continental Airlines	**Rte Risk Stage I**	**Rte Risk Stage II**	**Country Risk Stage 1**	**Country Risk Stage II**	**Regional Risk Stage I**	**Regional Risk Stage 2**	**Route MS**	**Country MS**	**Regional MS**	**Route HHI**	**Country HHI**	**Regional HHI**	**Route LF**	**Country LF**	**Regional LF**	**Route Foreign Comp**	**Country Foreign Comp**	**Regional Foreign Comp**
Mean	0.0397	0.2184	1.3603	7.4815	13.4658	24.4981	0.7485	0.1773	0.0801	0.7785	0.3249	0.0950	0.8295	0.8292	0.8298	0.8000	3.2500	23.6000
Standard Error	0.0158	0.0872	0.5082	2.7952	3.7119	2.4464	0.0704	0.0467	0.0031	0.0609	0.0417	0.0015	0.0070	0.0060	0.0009	0.2000	0.4523	1.5600
Median	0.0000	0.0000	0.0002	0.0011	5.3759	19.1662	0.9923	0.1401	0.0868	0.9847	0.2910	0.0919	0.8256	0.8349	0.8318	1.0000	2.5000	27.0000
Mode	0.0000	0.0000	0.0000	0.0000	5.3759	19.1662	1.0000	0.0615	0.0868	1.0000	0.2014	0.0919	#N/A	0.8355	0.8318	0.0000	2.0000	27.0000
Std Dev	0.0709	0.3898	2.2728	12.5004	16.6002	10.9407	0.3150	0.2088	0.0138	0.2725	0.1864	0.0065	0.0311	0.0269	0.0041	0.8944	2.0229	6.9767
Sample Variance	0.0050	0.1519	5.1656	156.259	275.565	119.699	0.0992	0.0436	0.0002	0.0742	0.0347	0.0000	0.0010	0.0007	0.0000	0.8000	4.0921	48.6737
Kurtosis	3.1863	3.1863	2.5418	2.5418	0.6985	0.6985	-1.0294	11.556	0.6985	-1.4399	5.3433	0.6985	0.1349	0.7024	0.6985	0.2245	-0.6860	0.6985
Skewness	1.8873	1.8873	1.8140	1.8140	1.6245	1.6245	-0.7386	3.2015	-1.6245	-0.6385	1.9417	1.6245	-0.0487	0.4232	-1.6245	0.9219	0.8504	-1.6245
Range	0.2520	1.3863	7.1049	39.0767	40.4496	26.6593	0.9095	0.9388	0.0335	0.6996	0.8130	0.0158	0.1194	0.1092	0.0100	3.0000	6.0000	17.0000
Min	0.0000	0.0000	0.0000	0.0000	5.3759	19.1662	0.0905	0.0287	0.0533	0.3004	0.1241	0.0919	0.7666	0.7768	0.8218	0.0000	1.0000	10.0000
Max	0.2520	1.3863	7.1049	39.0767	45.8255	45.8255	1.0000	0.9675	0.0868	1.0000	0.9371	0.1077	0.8860	0.8860	0.8318	3.0000	7.0000	27.0000
Sum	0.7941	4.3677	27.205	149.630	269.31	489.961	14.970	3.5453	1.6027	15.570	6.4985	1.9005	16.590	16.583	16.595	16.000	65.000	472.000
Count	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000	20.0000
Confidence Level (95.0%)	0.0332	0.1824	1.0637	5.8504	7.7691	5.1204	0.1474	0.0977	0.0064	0.1275	0.0872	0.0030	0.0146	0.0126	0.0019	0.4186	0.9467	3.2652

Delta Airlines	Rte Risk Stage I	Rte Risk Stage II	Country Risk Stage 1	Country Risk Stage II	Regional Risk Stage I	Regional Risk Stage 2	Route MS	Country MS	Regional MS	Route HHI	Country HHI	Regional HHI	Route LF	Country LF	Regional LF	Route Foreign Comp	Country Foreign Comp	Regional Foreign Comp
Mean	0.0183	0.1095	0.7316	3.6354	10.9035	84.0136	0.5543	0.1430	0.1019	0.6567	0.2725	0.0950	0.8171	0.8205	0.8154	1.0571	3.6286	23.6000
Standard Error	0.0063	0.0483	0.0685	0.4464	0.1420	0.8943	0.0652	0.0146	0.0046	0.0517	0.0195	0.0011	0.0098	0.0071	0.0005	0.2128	0.3407	1.1662
Median	0.0077	0.0359	0.7159	2.8641	11.3174	86.6209	0.5226	0.0973	0.1152	0.5685	0.2603	0.0919	0.8256	0.8247	0.8169	1.0000	3.0000	27.0000
Mode	0.0000	0.0000	1.2943	5.1773	11.3174	86.6209	1.0000	0.0791	0.1152	1.0000	0.2014	0.0919	0.8889	0.8546	0.8169	0.0000	2.0000	27.0000
Std Dev	0.0370	0.2856	0.4051	2.6412	0.8400	5.2906	0.3860	0.0864	0.0270	0.3056	0.1153	0.0064	0.0580	0.0419	0.0029	1.2589	2.0159	6.8993
Sample Variance	0.0014	0.0816	0.1641	6.9758	0.7055	27.9906	0.1490	0.0075	0.0007	0.0934	0.0133	0.0000	0.0034	0.0018	0.0000	1.5849	4.0639	47.6000
Kurtosis	10.2983	14.2410	-1.0628	2.4151	0.4830	0.4830	-1.6744	-1.3302	0.4830	-1.6387	-0.6270	0.4830	-0.1102	0.6947	0.4830	0.4151	-1.2178	0.4830
Skewness	3.1965	3.8113	0.1093	1.3454	-1.5680	-1.5680	0.0315	0.3939	-1.5680	-0.0008	0.5018	1.5680	-0.6029	-0.8103	-1.5680	1.1062	0.4522	-1.5680
Range	0.1698	1.3585	1.4992	12.2487	2.0697	13.0362	0.9967	0.2697	0.0666	0.8697	0.3894	0.0158	0.2361	0.1665	0.0072	4.0000	6.0000	17.0000
Min	0.0000	0.0000	0.0638	0.2552	9.2478	73.5846	0.0033	0.0113	0.0487	0.1303	0.1241	0.0919	0.6731	0.7254	0.8097	0.0000	1.0000	10.0000
Max	0.1698	1.3585	1.5630	12.5039	11.3174	86.6209	1.0000	0.2810	0.1152	1.0000	0.5135	0.1077	0.9091	0.8920	0.8169	4.0000	7.0000	27.0000
Sum	0.6394	3.8332	25.606	127.23	381.62	2940.47	19.3994	5.0041	3.5674	22.9840	9.5367	3.3259	28.5975	28.7187	28.5397	37.0000	127.000	826.000
Count	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000	35.0000
Confidence Level (95.0%)	0.0127	0.0981	0.1392	0.9073	0.2885	1.8174	0.1326	0.0297	0.0093	0.1050	0.0396	0.0022	0.0199	0.0144	0.0010	0.4325	0.6925	2.3700

United Airlines	**Rte Risk Stage I**	**Rte Risk Stage II**	**Country Risk Stage 1**	**Country Risk Stage II**	**Regional Risk Stage I**	**Regional Risk Stage 2**	**Route MS**	**Country MS**	**Regional MS**	**Route HHI**	**Country HHI**	**Regional HHI**	**Route LF**	**Country LF**	**Regional LF**	**Route Foreign Comp**	**Country Foreign Comp**	**Regional Foreign Comp**
Mean	0.0610	0.4475	2.2785	19.1506	2.6579	18.7804	0.4628	0.2074	0.1644	0.5593	0.2858	0.0988	0.8217	0.8196	0.7964	1.4706	3.8824	19.5000
Standard Error	0.0136	0.0775	0.3024	2.1385	0.3617	3.5158	0.0586	0.0189	0.0080	0.0486	0.0162	0.0014	0.0164	0.0151	0.0036	0.2283	0.3626	1.4694
Median	0.0260	0.3053	2.2621	21.9221	0.8120	0.8351	0.3846	0.2125	0.1237	0.5064	0.2603	0.0919	0.8478	0.8423	0.7781	1.0000	4.0000	27.0000
Mode	0.0256	0.3069	3.1934	36.2009	0.8120	0.8351	1.0000	0.2474	0.1237	1.0000	0.3217	0.0919	#N/A	0.8706	0.7781	0.0000	2.0000	27.0000
Std Dev	0.0793	0.4519	1.7632	12.4693	2.1088	20.5005	0.3417	0.1099	0.0465	0.2833	0.0946	0.0080	0.0958	0.0881	0.0209	1.3311	2.1144	8.5679
Sample Variance	0.0063	0.2042	3.1089	155.482	4.4471	420.266	0.1168	0.0121	0.0022	0.0803	0.0090	0.0001	0.0092	0.0078	0.0004	1.7718	4.4706	73.4091
Kurtosis	0.9190	-0.6378	-1.3924	-1.3790	-2.0637	-2.0637	-1.0164	-0.8060	-2.0637	-1.0515	-0.2554	-2.0637	18.493	26.251	-2.0637	-0.0895	-1.5750	-2.0637
Skewness	1.5157	0.8466	0.2448	-0.1534	0.2480	0.2480	0.3676	0.1157	0.2480	0.5778	0.4434	0.2480	-3.7434	-4.8498	0.2480	0.6813	0.1230	-0.2480
Range	0.2369	1.3030	4.8969	36.2009	4.1842	40.6760	0.9990	0.3819	0.0922	0.8697	0.3694	0.0158	0.6196	0.5212	0.0415	5.0000	6.0000	17.0000
Min	0.0000	0.0000	0.0000	0.0000	0.8120	0.8351	0.0010	0.0011	0.1237	0.1303	0.1441	0.0919	0.3494	0.3494	0.7781	0.0000	1.0000	10.0000
Max	0.2369	1.3030	4.8969	36.2009	4.9962	41.5111	1.0000	0.3830	0.2159	1.0000	0.5135	0.1077	0.9690	0.8706	0.8196	5.0000	7.0000	27.0000
Sum	2.0748	15.215	77.470	651.119	90.370	638.533	15.734	7.0511	5.5890	19.017	9.7173	3.3608	27.937	27.866	27.076	50.000	132.000	663.000
Count	34.0000	34.0000	34.0000	34.0000	34.000	34.0000	34.0000	34.0000	34.0000	34.0000	34.0000	34.0000	34.0000	34.0000	34.0000	34.0000	34.0000	34.0000
Confidence Level (95.0%)	0.0277	0.1577	0.6152	4.3507	0.7358	7.1530	0.1192	0.0384	0.0162	0.0989	0.0330	0.0028	0.0334	0.0307	0.0073	0.4644	0.7377	2.9895

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Blue Dart Submission Form

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Position/Title: __Student_______________________________________

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Status: [x] Student [ ] Faculty [ ] Staff [ ] Other

Optimal Media Outlet (optional):
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Optimal Time of Publication (optional):
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{*e.g., anniversary of a specific event, etc.*}

General Category / Classification:
[ ] core values
[ ] war on terror
[x] warfighting
[ ] command
[ ] culture & language
[x] international security
[x] strategy
[ ] leadership & ethics
[ ] doctrine
[ ] other (specify):
____

Suggested Headline: ______CRAF at Risk________________
{*e.g., I Was Just Following Orders*}

Keywords: ______CRAF, risk___________________
{*e.g., leadership, ethics, Nuremburg, Giessen, intimidation, chain of command*}
Blue Dart Text {either type in or cut and paste from another document}—Limit to approximately 750 words:

The Civil Reserve Air Fleet (CRAF) provides a large amount of cargo and passenger capacity to the Department of Defense (DoD) during peacetime and times of war. Participation in the CRAF program is completely voluntary and the airlines that do participate risk economic hardships if the CRAF fleet is activated.

The airline industry is a volatile market that is greatly impacted by even the smallest economic fluctuations. Airlines measure risk in their ability to respond to world events and adjust their schedules, to maximize revenue. In the years 2000-2009, the airline industry underwent a transformation that decreased their flexibility. In 2009, there was a total of 7,132 commercial aircraft in service, a reduction of 323 aircraft from the previous year and a staggering 18.3 percent less than were in service in 2000[8]. The downsizing of assets in the airline industry directly impacts the CRAF, but also limits the options of the carriers to absorb shocks to the system if the CRAF is activated. The airlines must now weigh their CRAF commitment with respect to smaller fleets, which leaves little flexibility in a very volatile market.

Airlines that commit a large number of a specific types of aircraft to the CRAF and use that same aircraft type to service a high-value or high-volume route, country or region, risk significant financial loss if the CRAF is activated. For example, multiple U.S. and foreign airlines service the route from New York to London and the load factors are typically above 80 percent. These are indicators of a route that is at a high level of risk, if the aircraft used to service this route are also heavily committed to the CRAF. Routes that have high levels of foreign competition or the airline has a large market share leads to higher risk. These strategically important routes are at significant risk during CRAF activation, and U.S airlines may be economically crippled if they are unable to service these routes, or if they completely lose access to them in the future.

U.S. air carriers would likely be greatly impacted by CRAF activation, with the effects growing towards Stage III activation. Although there is little empirical

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[8] U.S. Department of Transportation. *FAA Aerospace Forecast Fiscal Years 2010-2030,* Federal Aviation Administration Aviation Policy and Plans: Washington D.C., 2010.

evidence on how the airlines are affected by the economic factors of CRAF activation we do know that network carriers are essential to CRAF viability. CRAF network carriers provide 90 percent of passenger capacity for peacetime and contingency operations[9]. Some carriers may not be able to survive the loss of revenue due to CRAF activation without supplemental government funding or financing. This economic stress will almost certainly negatively impact CRAF capabilities to support Department of Defense transportation requirements. The U.S. military must have a sound understanding of how the level of CRAF activation will affect the U.S. airlines, and also how this will eventually affect U.S. military operational capabilities.

The U.S. military must be aware of how its decisions will affect the airlines, and in turn the overall health of the CRAF fleet. The economic impact of CRAF activation is important to the airlines and the Department of Defense. Leaders need a better understanding of the far-reaching impact of CRAF activation on the airlines and ultimately the Department of Defense's capabilities.

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[9] General Accounting Office. *Military Airlift: DOD Should Take Steps to Strengthen Management of the Civil Reserve Air Fleet Program:* GAO Report 09-625. Washington D.C. September 2009.

The Impact of Long-Run CRAF Activation Risk on International Routes

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Introduction

The Civil Reserve Air Fleet (CRAF) provides a large amount of cargo and passenger capacity to the Department of Defense during peacetime and times of war. Participation in the CRAF program is completely voluntary and the airlines that do participate risk economic hardships if the CRAF fleet is activated.

This research used publicly available data, collected by the U.S. Department of Transportation, on international flights from specific U.S. airports. The data contained information on market share, number of competitors, level of competition, type of aircraft used and the load factor for all airlines (U.S. and foreign) from May 2009 to May 2010. In addition CRAF commitment data for each airline was compiled from Air Mobility Command.

The aggregation of this data was used to create a model to predict risk scores based on the amount of aircraft committed to the CRAF and the type of aircraft being flown on specific routes. This risk score was then compared to variables such as market share, load factor and foreign competition to determine if a positive or negative relationship between the variables existed.

Research Goals

- Determine which U.S. carriers have the highest level of risk during activation
- Analyze which international routes are the most at risk
- Determine the factors/predictors of an airline/route with a high level of risk
- Help the U.S. military understand how the level of CRAF activation will affect the U.S. airlines, and how this could affect U.S. military operational capabilities

AIR FORCE INSTITUTE OF TECHNOLOGY

General Framework

	CRAF Activation Risk Score		
	Low	Moderate	High
Route	< 0.5	$.5 > R \le 1.0$	> 1.0
Country	< 15	$15 > R \le 30$	> 30
Region	< 15	$15 > R \le 30$	> 30

	Mean Risk Scores					
Airline	Route Stage I	Route Stage II	Country Stage I	Country Stage II	Region Stage I	Region Stage II
AA	0.2956	1.0192	9.0901	33.2859	21.9985	87.5529
DL	0.0183	0.1095	0.7316	3.6354	10.9035	84.0136
CO	0.0397	0.2184	1.3603	7.4815	13.4658	24.4981
UA	0.0610	0.4475	2.2785	19.1506	2.6579	18.7804

	CRAF Stage I		CRAF Stage II	
Variables	Route Risk	Country Risk	Route Risk	Country Risk
Intercept	0.345	8.0342	1.1452	24.1832
	(0.791)	(-1.0276)	(-0.7792)	(0.8738)
Market Share	0.425 **	8.9293 +	1.5939 **	36.4834 *
	(2.980)	(-1.6825)	(-3.3173)	(1.9421)
HHI	-0.17	-8.0152	-0.7826	-36.2042 *
	(-.925)	(-1.5674)	(-1.2651)	(-2.0002)
Load Factor	0.734 +	-11.3900	-2.3941 +	-34.0234
	(-1.692)	(-1.2551)	(-1.636)	(-1.0593)
Foreign Comp	0.09 *	0.8965 **	0.3124 **	3.4344 **
	(2.331)	(-2.4647)	(-2.4062)	(2.6674)
AA	.863 **	10.7911 **	2.8726 **	35.2082 **
	(3.905)	(-2.695)	(-3.8526)	(2.4841)
DL	0.107	0.8723	0.5546	6.9508
	(.485)	(-0.2627)	(-0.7465)	(0.5914)
UA	0.084	2.1859	0.5524	16.9271
	(.429)	(-0.6706)	(-0.8401)	(1.4673)
Atlantic Reg	0.058	1.1756	0.2819	7.0253
	(.304)	(-0.408)	(-0.4402)	(0.6890)
AA x Atl Reg	-0.709 **	-8.947 *	-2.4152 **	-29.3606 +
	(-2.950)	(-2.0104)	(-2.9807)	(-1.8639)
DL x Atl Reg	-0.123	-2.0518	-0.6993	-13.7789
	(-.509)	(-0.5378)	(-0.8546)	(-1.0204)
UA x Atl Reg	-0.054	-3.5080	-0.3574	-17.7298
	(-.242)	(-0.8876)	(-0.4755)	(-1.2674)
N	122	51	122	51
R^2	0.291	0.389	0.291	0.419
Adj R^2	0.22	0.216	0.220	0.255
F	4.1074 ***	2.2539 *	4.099 ***	2.556 **
df	121	50	121	50

1: t-statistics are in parentheses, *** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$ + $p < 0.1$

Application

$$\text{Route Risk}_i = \sum_{a}^{n} (\% AC_a\, Route_i\, \% AC_a\, CRAF\, Stg_i * \% AC_a Total\, Dep_i)$$

	Dependent Variable		Independent Variables			
AA	Risk Stage I	Risk Stage II	MarketShare	Load Factor	HHI	Foreign Comp
DL	Risk Stage I	Risk Stage II	MarketShare	Load Factor	HHI	Foreign Comp
CO	Risk Stage I	Risk Stage II	MarketShare	Load Factor	HHI	Foreign Comp
UA	Risk Stage I	Risk Stage II	MarketShare	Load Factor	HHI	Foreign Comp

Chicago (ORD)	Brussels (BRU) Copenhagen (CPH) Dublin (DUB) Frankfurt (FRA) London (LHR, LGW) Manchester (MAN) Munich (MUC) Paris (ORY, CHG) Rome (ROM)	Hong Kong (HKG) Seoul (ICN) Tokyo (NRT) Beijing (PEK) Shanghai (PVG)

Example Route City-Pairs

Motivation

- The CRAF is vital to U.S. military operations and the volatility of the airline industry demands that TRANSCOM fully understand how CRAF activation could affect military readiness.
- U.S. carriers may not survive the loss of revenue due to activation, negatively impacting CRAF capability to support DoD transportation requirements

Impacts/Contributions

- There are strategic routes, countries and regions in the world that are at risk for some of the network carriers. This is related to the dependence on specific aircraft types for high revenue routes when those same aircraft are also highly committed to the CRAF

Collaboration

Air Mobility Command/A3B

Air Mobility Command/A9

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