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Missile Defensive Systems and the Civil Reserve Air Fleet

Glen R. Downing
Lieutenant Colonel, USAF

Air War College
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Foreword

One of the United States' greatest military advantages is rapid global mobility. The Civil Reserve Air Fleet (CRAF) provides a crucial supplement to the military's mobility resources in time of war or national emergency. The proliferation of man-portable air defense systems (MANPADS), however, poses a growing threat to the CRAF and its critical airlift capacity.

In this study, Lt Col Glen Downing describes the US government's historical and potential future uses of the CRAF during contingency operations. He examines current CRAF policies, the operating environment, and the MANPAD threat, describing the negative consequences of the shoot down of a CRAF airliner. Positing several options to counter the threat, he analyzes each following the parameters of unit cost, operating cost, funding sources, insurability, and crew training. The study concludes with a thoughtful recommendation to the Department of Defense on a course of action to confront the MANPADS threat to the CRAF.

As with all Maxwell Papers, the Air War College publishes this study in the spirit of academic freedom and open debate. We encourage your engagement on the issues the paper raises and solicit your responses.

MAURICE H. FORSYTH
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About the Author

Lt Col Glen "Tron" Downing, USAF, is a graduate of the Air War College, Class of 2009. Previously, he served as the commander of the 32nd Student Squadron, Squadron Officer College, Maxwell AFB, Alabama. He also completed tours at Scott AFB, Illinois; Pope AFB, North Carolina; Little Rock AFB, Arkansas; and Davis-Monthan AFB, Arizona.

Colonel Downing entered the Air Force as a distinguished graduate of the Reserve Officer Training Corps in 1990 following graduation from Iowa State University. He is a senior navigator with more than 1,700 hours in the C-130E, EC-130H, T-43, and T-37. He was a distinguished graduate of specialized undergraduate navigator training, C-130 initial qualification training, and C-130 instructor qualification training. A graduate of the US Air Force Weapons School, he was qualified as an instructor electronic warfare officer in the EC-130 and instructor/flight examiner navigator in the C-130. He holds the master of military arts and sciences in theater operations from the Advanced Military Studies Program, School of Advanced Military Studies, US Army Command and General Staff College, Fort Leavenworth, Kansas, and is a graduate of the Army Command and General Staff Officer Course, Fort Leavenworth, Kansas. He also holds a master of science in operations management from the University of Arkansas, Fayetteville, Arkansas.

Following graduation from the Air War College, Colonel Downing was selected as chief, Strategy and Assessments Division, Secretary of the Air Force Office of Public Affairs, The Pentagon, Washington, DC.

Introduction

Imagine yourself executing a tactical departure from Baghdad International Airport (IAP) in your sleek 1979 Airbus A300. You and your crew are spiraling upward in a steep climb at 170 knots after a successful day of delivering US mail to troops. Passing through 8,000 feet, you hear a loud noise, and the plane begins to shudder violently. Your engines are operating normally, but you begin to notice the hydraulic pressure decreasing. As you glance out the window, your wing is on fire. Ten feet of the trailing edge of the left wing is gone or damaged by fire. Within a minute, you have lost all hydraulic pressure and your flight controls are inoperative. Your task, get the plane safely on the ground, saving your crew and an invaluable asset.[1]

This exact scenario played out in November 2003. A Belgian-flagged DHL aircraft, operated by a Belgian and British crew, safely returned to Baghdad IAP after an attack by an Iraqi terrorist group firing a man-portable air defense system (MANPADS) rocket. This incident, and an attack on an Arkia Israeli Airlines Boeing 757 in Kenya a year earlier, heightened public awareness of the MANPADS threat. Congress responded by submitting multiple bills demanding commercial airliners be equipped with missile defensive systems. Time and the lack of subsequent incidents have lessened the urgency and attention devoted to this effort. This paper will show that US dependence on the Civil Reserve Air Fleet (CRAF) and contract aircraft, combined with a significant threat, demands equipping at least a portion of the US-flagged commercial airliner fleet with a missile defensive system.[2]

The methodology is to investigate the US government's use of commercial aircraft and specifically, the CRAF, during contingency operations with an overview of the CRAF, the number of aircraft participating, and strategic plans for use in a major theater war. Next is a discussion of CRAF usage since 2001, examining current policies, delivery methodologies, and operating environment. Examination of future concepts of operation and potential enemy strategies to defeat those concepts follows.

The terrorist threat is carefully examined to include proliferation of shoulder-fired weapons with an historical review of attacks on commercial aircraft. Possible information warfare consequences on public confidence of a commercial airliner shoot down are described, and then a description of friendly countermeasures follows.

The recommendations focus on the required force structure of commercial aircraft equipped with missile defensive systems. The driving factors are cargo/passenger throughput and cost: unit cost, operating cost, funding sources, consideration of insurability, and crew training.

The Civil Reserve Air Fleet is both a "program" and a "contract." As a program, the CRAF represents the number and capability of aircraft available for mobilization to augment the US military's organic airlift fleet. As a contract, the CRAF represents contract guarantees for a "fixed buy" of the projected Department of Defense (DOD) commercial business over the coming year and increased competitiveness for an "expansion buy" to fill the gap between fixed buy and actual needs.[3] Throughout the paper, the use of the term "CRAF" references mobilization or program. I will use "commercial" contract or airlift to refer to the contractual aspects of the CRAF.

Civil Reserve Air Fleet Overview

The Civil Reserve Air Fleet is a critical component of the Defense Transportation System developed to supplement organic government resources in time of war or national emergency. Current studies indicate the US government will rely on the CRAF to move over 40 percent of the total air cargo requirement in a contingency operation. The experience of the first Persian Gulf War suggests that the CRAF may also move over 85 percent of the total passenger requirement.[4]

The CRAF has three segments: international, national, and aeromedical. The international segment has both a long-range and a short-range section. The long-range section provides extended intercontinental cargo and passenger airlift using predominantly civil wide-body aircraft. As of June 2008, there are 312 international long-range cargo and 582 international long-range passenger aircraft allocated to the CRAF.[5] The short-range section provides support in "near offshore operations."[6] US airlines commit 11 international short-range cargo and 245 short-range passenger aircraft to the CRAF.[7] The international segment performs missions the USAF would normally use C-5 and C-17 aircraft to perform.

The national segment of the CRAF helps the government respond to increased airlift requirements within the continental United States and Alaska. Transportation requirements from military bases to seaports of embarkation and response in support of the Department of Homeland Security (DHS) are examples of missions accomplished by the national segment. Aircraft in this segment have at least 75 seats and are capable of carrying at least 32,000 lb. of cargo, making them roughly equivalent to the capability of the USAF C-130.[8] Domestic air carriers are committed to provide 36 national/domestic aircraft and another four aircraft dedicated to Alaskan airlift.[9]

The last segment, CRAF aeromedical evacuation, transports patients and casualties. Fifty Boeing 767s operated by four major airlines have been specially modified to carry ambulatory and nonambulatory patients as well as medical supplies and equipment.[10] Since the DOD no longer has dedicated aeromedical-evacuation assets, this segment allows organic airlift assets to continue moving cargo rather than be diverted to this critical and high-profile mission.[11]

The CRAF is a very flexible tool providing for modular activations of portions of each segment, and the US Transportation Command plans include a three-stage activation of the CRAF assets. Stage I is a "Committed Expansion" and supports small, regional crises around the world. A "Defense Airlift Emergency" calls for the activation of CRAF stage II in support of a major conflict such as the first Persian Gulf War and the more recent Operation Iraqi Freedom. Finally, a "National Emergency" activates stage III of CRAF as our nation mobilizes for war.[12] Total aircraft committed to the CRAF as of June 2008 was 1,240 (see Appendix A).[13]

The CRAF commercial carrier participants must meet other stringent criteria. They must be US owned, Federal Aviation Regulations Part 121 certified, and operate US-registered aircraft. A company must commit a minimum of 30 percent of its passenger fleet and 15 percent of its cargo fleet. Additionally, each operator provides four crews per aircraft. In return, participants received $379 million in contract guarantees in 2007 and an estimated $2.1 billion in additional business from the Department of Defense.[14] Opportunities for lucrative contract business have led to remarkable levels of volunteerism within the CRAF. Often this volunteerism has averted CRAF activation. In the Korean War, CRAF member carriers moved 67 percent of the passengers and 56 percent of the cargo.[15] Civil aircraft also moved over 11 million passengers and 1.3 million tons of cargo during the Vietnam conflict. All of this without activation of any stage of the CRAF.[16]

Historical Usage

Although the CRAF is over 57 years old, formal activation has occurred only twice, for Operation Desert Shield/Storm and for Operation Iraqi Freedom. These activations generated favorable results for both the airlines and the DOD. During Operation Desert Shield/Storm, the CRAF carried 25 percent of the cargo and 85 percent of the passengers deploying to the Middle East following activation of the long-range portions of stages I and II from August 1990 to May 1991.[17]

Military Airlift Command (MAC) used the CRAF for missions most frequently from the continental United States directly to Saudi Arabia and the Gulf States. This routing took best advantage of the capabilities of commercial wide-body aircraft and avoided complications that might have arisen from operating through commercial airfields in Europe. MAC provided tactical experts and intelligence personnel to brief commercial crews on operational and security concerns. Planners varied CRAF routing in order to avoid predictability; however, the carriers requested crews only land in the area of responsibility (AOR) during daylight hours. This additional restriction posed no significant tactical risk since those airfields were beyond the reach of any real threat excluding Scud missile attack.[18]

The greatest impact of the Scud threat was psychological, but there were some operational impacts as well. Commercial aircraft are not compatible with military aircrew chemical defense gear. This makes it extremely difficult to protect a crew from chemical attack while airborne. Once on the ground, ground chemical defense equipment will provide protection, but the DOD did not issue this equipment until late in the conflict, and commercial crews received inadequate training. The media news barrage on the Scud threat and the full chemical defense protection of the commercial crews' military counterparts led to declining morale and some mission refusal of CRAF aircrew.[19]

Scud alerts were the same for commercial crews and military crews. They first assessed the ability to stop all ground operations and immediately take off to protect the aircraft from attack. If unable, they sought shelter, hoping to have chemical defense suits. In at least one instance, a CRAF crew came under Scud alert at Dhahran, Saudi Arabia, took off with too little fuel to depart the AOR, and headed for Riyadh. While landing at Riyadh, they came under a subsequent Scud alert. With no options left, they landed and immediately sought shelter.[20] Despite situations such as this, there were no personnel injuries or damage to aircraft during the entire period of activation during Desert Storm.[21]

CRAF activation for Operation Iraqi Freedom was very short, lasting from February to June 2003. This fact obscures a significantly increased DOD reliance on commercial contract carriers in the period following 2003 and commercial volunteerism due to a decreasing commercial market following the events of September 2001. When measured in terms of percentage of total revenue, DOD cargo business has tripled, and DOD passenger business doubled when compared to pre–Iraqi Freedom numbers.[22] Obviously, commercial aircraft were and are critical to US success in the AOR.

During the Army's initial deployment to Iraq, CRAF assets operated mainly into Kuwait City International Airport (KCIA), which served as both a military and commercial hub. The CRAF moved primarily passengers and some limited cargo. Disembarking passengers linked up with equipment moved by sealift to the Ash Shuaybah seaport or drawn from prepositioned stock at Camp Arifjan.[23]

The invasion of Iraq resulted in the capture of several airfields later converted to US military use. However, CRAF aircraft continued to operate primarily out of KCIA due to chemical/biological and surface-to-air threats and the lack of ground security at many sites. Baghdad IAP began commercial operation in June 2004 with Balad Air Base following soon after. Today, contracted commercial airlift accounts for nearly 50 percent of all intratheater airlift.[24]

Major operations still move through the KCIA hub, but several fields in Iraq are now open for commercial business. Many carriers are using their own infrastructure to accomplish military missions. One example is United Parcel Service (UPS). UPS operates from its hub in the United Arab Emirates and flies direct to commercial and military airports in Iraq. Final delivery is via UPS ground. This entire operation is largely outside the control of US Transportation Command, yet reflects the reliance of the military on commercial airlift support and the return to relative normalcy in Iraq.[25]

Future Use

The future battlefield will be nonlinear and noncontiguous, just as Afghanistan and Iraq are today. Ground and air operations will occur simultaneously in multiple areas. Limited security and space will prevent the establishment of large logistical areas on the ground. Airlift assets will support multiple units flowing parallel to each other to multiple staging areas.[26]

Rapid force projection, or Global Strike, will grow in importance. The key enabler for both the deployment and sustainment of Global Strike assets is operational maneuver from strategic distances (OMFSD). OMFSD is the latest iteration of the direct delivery concept developed in the 1970s and a key driver of the C-17 acquisition.[27]

A couple challenges prevent the realization of these concepts. First, a current US Army heavy armored corps weighs approximately 1 million tons and relies on sealift to deploy. Much of the equipment is air transportable by only the C-5. If every C-5 flew dedicated support to movement of the corps and no sorties were lost, it would still take 66 days to move the unit, contrasted with a sail time to Kuwait of less than 45 days.[28] Commercial airlift can do little to offset the demand since the CRAF lacks a robust outsize or oversize cargo capability. Sealift is not going out of business anytime soon.

Second, the quickest way to defeat rapid force projection is with antiaccess tactics, specifically port denial. The most effective methods of port denial available are weapons of mass destruction and MANPADS. As demonstrated repeatedly through two CRAF activations, commercial assets lack the ability to cope with either, effectively relegating the CRAF to passenger movement and resupply missions to rear areas until security is established.

Without major changes in equipment and training, reception, staging, onward movement, and integration (RSOI) in the future will continue to look much like the current Iraqi operation. RSOI is the process used by land forces to receive forces in theater, match them to equipment and units, move them forward toward the battle, and integrate them into existing force structures. Commercial airlift will fly to a safe, secure hub where passengers and cargo will transition to other means of transportation for onward movement. Post conflict will enable an eventual return to normalcy through small steps as seen from 2004 to the present in Iraq.[29]

The United States was incredibly fortunate in Operation Iraqi Freedom to have a commercial hub with a seaport of debarkation and prepositioned equipment. This factor greatly facilitated RSOI. Military operations at KCIA for 12 years prior to this deployment further enhanced security and the ability to conduct significant logistical improvements. A Naval War College study shows the lack of a suitable airfield for CRAF use will result in a combatant commander entering combat operations with half his planned equipment and less than half of the planned forces due to the requirement for military airlift to move troops and equipment from an intermediate hub to the theater.[30] If the invasion of Afghanistan had been a conventional operation, it would have taken months to get the invasion force in place, affording the enemy a great amount of time to prepare.

The Man-Portable Air Defense System Threat

Man-portable air defense systems are a growing threat to civil aviation. As antiaccess weapons, MANPADSs are readily available to both state and nonstate actors. As a terror weapon, they are the next logical step for nonstate actors. Attacks against commercial aircraft, whether operating as part of the CRAF or in the civil air transport system, are bound to have dramatic effects on public support for a conflict and confidence in the safety of the air transport system. As a result, defense against these threats is critical.

MANPADSs are predominately shoulder-fired missiles manufactured in nearly 20 countries worldwide. These countries have produced over one million weapons to date. Approximately half of these are in current arsenals. The large number is not a problem in itself, but control of these weapons is questionable in many nations of the world. There are estimates ranging from 5,000 to 150,000 missiles currently in terrorist hands.[31]

Terrorists have acquired these weapons through several means including the black market, theft, and even conventional arms sales. The United States gave Afghanistan over 1,000 Stinger missiles and training in their use during the 1980s in order to repel the Soviet invasion.[32] Coalition forces captured over 5,500 Afghani MANPADSs of all makes by December 2002 with an unknown number still in circulation. Four to five thousand missiles of all makes and nationalities are available to insurgents in Iraq without further import of new weapons.[33]

Over two dozen nonstate actors acquired MANPADSs by 2001 (see Appendix B). It is unknown how many additional organizations have gained access to the weapons in the period since.[34] The weapons themselves weigh less than 40 pounds and are approximately 60 inches long, making it very easy to transport them from country to country. There are only a handful of countries without confirmed or suspected MANPADSs.[35]

There are differing opinions on the number of MANPADS attacks on civil aircraft since the 1970s (see table 1). The most widely accepted numbers are those produced by the US Transportation Security Administration (TSA) of 35 attacks resulting in 24 shoot downs and 640 deaths.[36] This statistic includes several aircraft types ranging from helicopters to multiengine turbofans.[37]

The Congressional Research Service did further analysis of the available data and found only six attacks on large, commercial turbojets using MANPADS (see Appendix C). Two attacks resulted in catastrophic loss of the aircraft and all passengers. Three attacks resulted in substantial damage to aircraft, but no loss of life. One was a near miss.[38]

Table 1. MANPADS attacks on civil aircraft (*Adapted from* Loren Thompson, chief operating officer of the Lexington Institute and adjunct professor of Georgetown University, briefing, "MANPADS: Scale and Nature of the Threat," 12 November 2003, http://www.lexingtoninstitute.org/docs/614.pdf.)

Organization	*Period Covered*	*Number of Attacks*	*Number of Deaths*
TSA	1979–present	35	640
Central Intelligence Agency	1977–1996	27	400
Federal Bureau of Investigation	1970s–present	29	550
RAND	1975–1992	40	760
Jane's Defence	1996–2000	16	186

Perhaps more importantly, all but one of the attacks occurred in a known hostile zone.

Public Reaction to Potential Attack

The American public became acutely aware of the MANPADS threat after the near miss on the Israeli 757 in Kenya following the 2001 attack on the World Trade Center. In response, Congress introduced two bills directed at countering the threat. The first, the Commercial Airline Missile Defense Act, called for the development and installation of a missile defense system on all US-flagged commercial airliners. This bill died in committee.[39] The second, the Commercial Aviation MANPADS Defense Act, was a more comprehensive approach to counterproliferation and aircraft defense. This bill included international efforts to secure weapons and reduce their proliferation, intelligence sharing, airworthiness certification of defensive systems, and routine vulnerability assessments. This bill passed the House with a 423-0 vote. The Senate did not consider the bill after two readings.[40]

The failure of these bills led Rep. Steve Israel to introduce the Civil Reserve Air Fleet Missile Defense Pilot Program Act of 2007. The intent of this act was to require the Department of Defense to determine the need and feasibility of equipping CRAF aircraft with missile defense systems. This bill never made it out of committee.[41] In May 2009, Representative Israel attempted once again to launch a pilot program by reintroducing the bill to the House Armed Services Committee.[42]

Despite the challenges faced by the above bills, Congress has provided extensive funding for counter-MANPADS efforts over the last five years under the umbrella of the National Intelligence Reform Act of 2004. The DHS received $173 million over three years to develop and test missile defense systems for commercial aircraft. Nearly $19 million went to the DOD for ground-based defenses. The Department of State used $10 million for diplomatic efforts to curtail proliferations.[43]

These expenditures pale in comparison to the estimates of the loss of an aircraft to attack, from either MANPADS or other sources. RAND estimates the immediate cost of such an attack as $1 billion per aircraft, including hull loss and the death of passengers. Government reaction to the World Trade Center attacks resulted in a shutdown of the air traffic system. A similar shutdown may follow a MANPADS attack in the United States. A one-week shutdown of the air traffic system in response to an attack may cost as much as $3.4 billion with long-term losses of over $15 billion. The total potential cost of a one-month shutdown is estimated at over $70 billion.[44]

Defeating the Threat

Defeating the MANPADS threat requires a multilayered approach. RAND proposes seven levels of protection (see figure 1). The first, "striking and capturing the terrorists," is the fundamental goal of the Long War.[45] Despite the expenditure of a great deal of treasure and manpower, only eight of the 26 nonstate actors listed in Appendix B are currently under direct offensive pressure from the US military. Pressure across all the nonstate actors listed will require a great deal of international cooperation.

The second level is "preventing MANPADS acquisition by potential attackers."[46] This is a largely diplomatic effort requiring international cooperation, a counterproliferation effort climbing an uphill battle. As previously discussed, MANPADSs exist in most countries in the world. A great number of nonstate actors own and have demonstrated a propensity to use them. Therefore, this effort is akin to the

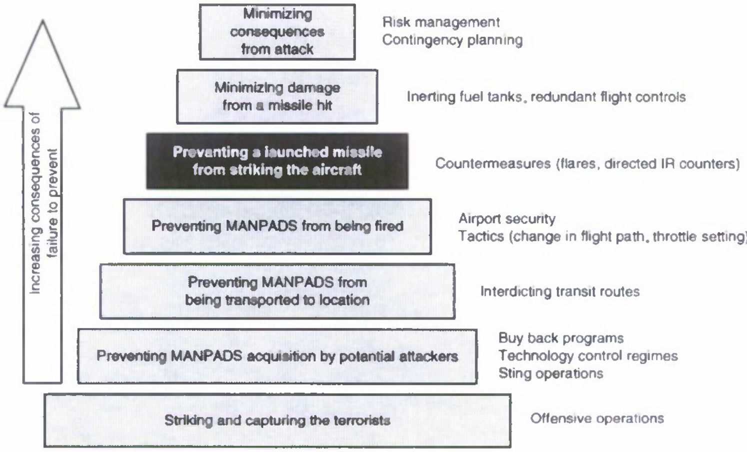

Figure 1. Levels of MANPADS protection (*Adapted from* James Chow, James Chiesa, Paul Dreyer, Mel Eisman, Theodore W. Karasik, Joel Kvitky, Sherrill Lingel, David Ochmanek, and Chad Shirley, *Protecting Commercial Aviation against the Shoulder-Fired Missile Threat,* Occasional Paper 106 [Santa Monica, CA: RAND Corp., 2005], 14.)

marginally successful global landmine ban. Buyback programs, technology control, law enforcement, and covert actions are examples of steps taken at this level.[47]

The third level of protection is "preventing MANPADS from being transported to location."[48] The international community has taken many notable steps here. The US DHS has greatly tightened the borders in improved monitoring of goods flowing in and out of the country. However, with a weapon as small as a shoulder-fired missile, total interdiction is extremely difficult. The weapons trade, narcotrafficking, and human trafficking are major funding streams for the very terrorists who would use MANPADSs to attack commercial airliners and serve as indicators of the difficulty of preventing transportation.

The fourth level of protection is "preventing MANPADS from being fired."[49] This is usually a two-pronged effort. The first is to secure the airport and low-level flight path of the threatened aircraft. Based on the capabilities of even the most basic MANPADS, police must sanitize an area six miles wide and 50 miles long for every runway. This means an area greater than 1,000 square miles with 10 million people to protect New York City's five major airports alone.[50]

The second prong of fire prevention is tactics. Commercial airlines currently fly spiral-down arrivals and spiral-up departures at several Middle East airports.[51] These procedures keep the aircraft flight path within the airfield security perimeter. Since most MANPADSs are infrared guided, or heat seeking, an additional benefit of these procedures is the reduced power settings required. Many other tactics are available to give the airliner some advantage over a potential threat but all, including the approaches and departures, require an increased level of training. This training includes simulator and actual aircraft use.

"Preventing a launched missile from striking the aircraft" is the fifth level of protection.[52] Missile defensive systems accomplish this task. Defensive systems are either ground based or aircraft based. The DHS just completed testing two aircraft-based systems, JETEYE and Guardian, and is also investigating an unmanned aerial system (UAS) to defend the immediate vicinity of an airport. The DOD recently tested a ground-based system known as Vigilant Eagle.[53]

BAE Systems JETEYE™ combines an airborne laser turret developed for the US Navy with an advanced missile detection and warning system. Guardian accomplishes the same using a directional infrared countermeasures system currently fielded by the US military. JETEYE permanently mounts to the aircraft whereas Guardian is a self-contained, pod-mounted system easily transferred from plane to plane. After a launch, the missile warning system detects and tracks the rocket. The laser or infrared system then interferes with the guidance system on the rocket creating a miss.[54]

The Department of Homeland Security UAS, known as Project Chloe, pairs a high-altitude unmanned aerial vehicle with the Guardian pod. Flying at 50,000 to 65,000 feet, the UAS will detect and engage any missile launched within its scanning footprint. Commercial airliners will operate free from the threat underneath the UAS combat air patrol, if you will.[55]

Vigilant Eagle is a collection of tower-mounted missile-detection and tracking systems and an active electronically scanned array. The towers surround an airport and detect any launches in the vicinity. The electronic array emits a high-powered microwave electromagnetic waveform interfering with the guidance system on the missile and causes a miss.[56]

Several efforts are underway to "minimize damage from a missile hit," the sixth level of protection.[57] Following lessons learned from recent major crashes, the aircraft industry began hardening aircraft in ways that have a second-order effect of increasing survival after a missile hit. The first is onboard fuel tank inerting. These systems eliminate explosive fuel vapors in empty fuel tanks minimizing the secondary explosions after a hit. A similar system may have prevented the TWA Flight 800 crash in 1996, and the Department of Defense uses it to increase the survivability of its cargo aircraft.[58]

Another improvement is propulsion-controlled aircraft. The DHL Airbus A300 attacked at Baghdad IAP in 2003 used throttle-only control to return to the field and safely land. The crew of a DC-10 used a similar technique to prevent a major aircraft disaster at Sioux City, Iowa, in 1989. Since the major heat sources on airliners are engines, engine loss is the most likely damage from a missile hit. Most aircraft have wing-mounted engines resulting in flight control loss as a secondary effect of the hit. Propulsion-controlled aircraft technology will allow aircraft with wing damage, but operable engines, to safely land after the attack.

The last layer of prevention is "minimizing consequences from attack."[59] The Federal Aviation Administration (FAA), International Civil Aviation Organization, and DOD all have strict accident response certification. All major airports are well equipped to handle a broad range of aircraft emergencies to include catastrophic crashes of wide-body aircraft. This is a major strength of the entire aviation system.

Recommendations

The layered approach is exactly the right answer for defeating the MANPADS threat. The best way to protect commercial aviation, and in fact any large aircraft, is to prevent attack in the first place. Unfortunately, this is not always possible. A proper amount of focus on defeating a launched missile is required.

Military aircraft routinely use flares for this purpose. Flares, however, present many problems, especially for commercial aircraft. Storage, assembly, and loading of the flares are large logistical challenges. Commercial airports would have to build explosive storage areas, and ground crews would have to learn how to load the flares within the incredibly dense confines of an international airport where the highly flammable flares or explosives could cause catastrophic damage. Additionally, the risk to the flying public from potential incidents with flares outweighs the risk presented by the MANPADS threat on a daily basis.

The current trend in defending large military aircraft is laser protection similar to the JETEYE and Guardian systems discussed previously. These systems present the best and most effective answer for defending commercial aircraft. The Vigilant Eagle and Project Chloe systems hold great promise as well.

But what aircraft need protection? How many systems does the United States need to purchase? There are four laser protection options ranging from equipping all US-flagged commercial airliners to none at all. The best choice depends on seven factors: unit costs, operating costs, funding, insurability, throughput penalties, crew training, and aircraft availability to the US DOD through the CRAF.

Option 1—Modify all US-flagged commercial airliners

There are 7,812 US-flagged commercial airliners currently in service. Of these, 39 are 90+ seat airliners, 1,008 are cargo, and 2,836 are regional aircraft of all propulsion types.[60] Equipping every one of them provides the greatest level of protection regardless of airfield or nation where the aircraft is operating. RAND estimates the total cost for fleet-wide modification at just over $11 billion. Unit cost, basically the cost of equipping one aircraft, is very close to the DHS target of $1 million.[61] Operating costs, taking into account system maintenance and fuel penalties, are $300,000 per aircraft per year or $2.1 billion per year for the fleet.[62]

Funding for a project of this magnitude is a challenge. In an environment of $700 billion financial industry bailouts, one would think $11 billion is easy to come by. However, the entire DHS budget is approximately $36 billion. A third of the budget would go to funding one program. Annual operating costs under a requirement such as this will be borne by the TSA. The annual TSA budget is $4.4 billion. Half of every dollar spent on transportation security in the United States would be committed to this one program.[63] Over time, these costs will likely transfer to the airlines. As industry builds new airframes, defensive systems will be a part of the aircraft and the flyaway costs. Operating costs will become routine and consequently passed along to customers: the US government under contract or the private citizens buying airline tickets.

There should be little change in the insurability of commercial airliners under a fleet-wide modification. Every aircraft will look similar, and federal regulation will likely force insurance companies to continue offering protection during routine air carrier operations. Insurability, however, has always been a factor in the eagerness of commercial air carriers to seek military contracts. It was one factor in the relatively slow uptake of commercial contract operations into Iraqi airfields. Some means of aircraft protection may enhance the insurability of these air carriers and thereby, their ability to begin operations at hostile fields sooner.

The planned DOD airlift throughput goals are unhampered by this solution. Though missile defensive systems will not give commercial aircraft access to every field in a hostile area, they may increase the number of those fields or allow a hub closer to the fight.

Fleet modification demands fleet-wide aircrew training. Current designs call for an automated defensive system, so equipment operation training would be minimal. However, airlines must continue to instruct aircraft defensive maneuvering. The challenge is not in aircrews' ability to learn and perform the maneuvers, but in assuring their ability to maintain defensive maneuvering proficiency. The requirement for military transport crews to train defensive maneuvering only once semiannually creates a perennial problem with proficiency. However, military crews intensively train prior to actual deployment to hostile areas in order to increase proficiency. The best solution for commercial aircrews is employment of defensive systems that have proven a high enough probability of success to obviate requirements for defensive maneuvering in response to a MANPADS attack.

The greatest benefit of this option would be an unlimited supply of aircraft for the CRAF and commercial contract. There would be no need to manage fleets by specific aircraft or tail number. This option offers the maximum flexibility, but misplaces the cost burden.

Option 2—Modify all CRAF aircraft

The Federal Aviation Administration admits the potential for MANPADS attacks in the United States; however, "there is no specific, credible information that terrorists have smuggled MANPADS into the United States."[64] The lack of a credible threat and the passage of time since 2001 have led to congressional inaction regarding defensive systems on commercial aircraft. The US Department of State, the International Civil Aviation Organization (the United Nations' organization that governs international aviation), and the Group of Eight nations (commonly known as G8) have all taken specific MANPADS nonproliferation actions. Despite the obvious recognition of MANPADS threats, these organizations join the US Congress in largely ignoring aircraft defensive systems.

The defense of US commercial aircraft operating overseas is likely to remain a private corporate burden and appropriately so. If private enterprise puts these aircraft in harm's way, private enterprise must bear the expense associated with protective equipment. The exception is the CRAF. The US government puts CRAF aircraft in harm's way, and it is reasonable to expect the Department of Defense to share the expense associated with the risk.

The first challenge to modifying all CRAF aircraft is to define a *CRAF aircraft*. There are CRAF activation and participation goals in numbers of aircraft. However, actual participation numbers usually exceed the activation goals significantly. Additionally, participation levels change on a monthly basis. What does remain relatively constant is an overall participation of approximately 1,100 aircraft.

Equipping only 1,100 aircraft may drive the cost per aircraft (unit cost) up; however, total program cost will drop due to a much smaller procurement number. Surprisingly, Northrop estimates unit costs of less than $1 million after only 200 systems. Operating costs may increase slightly over the $300,000 estimate due to the production of fewer spare parts.[65]

Funding will likely come from the DOD under a CRAF-only modification program. Installation costs in the $1–2 billion range are easier for the DOD to absorb than any other federal agency. Modification would occur once an aircraft is committed to the CRAF as occurred with floor-reinforcement cargo modification or the aeromedical-evacuation modification to CRAF-committed aircraft. The possibility of future purchase of limited numbers of "CRAF capable" aircraft directly off the assembly line is a possibility as well.

Defensive systems may enhance insurability, yet insurance remains a problem for the CRAF and commercial contracts. If commercial insurance providers cancel policies, as happened in Desert Storm, the FAA offers insurance protection under Title XIII of the US Code. There are several issues associated with Title XIII insurance including limits of coverage. For example, in a terrorist attack outside the designated hostile area, Title XIII likely will not cover the claim. There are also disagreements as to the value of aircraft themselves. A requirement for government and industry insurance reform must be met for operation of commercial aircraft in a hostile environment.

There would be enough aircraft over and above planning estimates to meet major-theater war-airlift goals, and throughput will not change under this plan. Air carriers may have to perform some tail number management to ensure that properly equipped aircraft are available, but that should be manageable.

Training costs would decrease since airlines will not have to train every crew, but the management burden would increase and crew flexibility would decrease. This might become a particular problem since large numbers of commercial crewmembers are also US Air Force Reserve or Air National Guard crewmembers. During a rapid CRAF mobilization, air carriers would likely lose a significant number of available crews.

This option would require the government to fund only those aircraft put at risk as part of a mobilized CRAF. Not all CRAF aircraft would see the same threat, however. In fact, the domestic segment might see very little threat. Additionally, modifying 1,100 airplanes would mean government funding for aircraft that were participating in the CRAF only for the contract airlift benefits that accrue from the program. This last should not be a government burden.

Option 3—Modify long-range international segment only

The most vulnerable segment of the CRAF is the long-range international and aeromedical-evacuation segments. These aircraft operate primarily in international and potentially hostile airspace far removed from the protection of the DHS. In June 2008, 944 aircraft participated in this segment of the CRAF. However, planning targets are limited to approximately 300 wide-body aircraft (see table 2 and Appendix A). This option requires federal funding of defensive systems for 300 wide-body aircraft and commercial-carrier funding for any additional CRAF participation above the planning targets.

The unit cost for 300 systems is likely the highest of the options presented. However, it is above the 200 systems Northrop says are needed to meet the $1 million per system target. Operating costs will also increase due to the low volume of spare parts.[66]

The DOD funding is the correct answer for 300 systems and is defensible under the current force structure models calling for the CRAF to deliver nearly 40 percent of the cargo and nearly all of the passengers to a major theater war.[67] Profit incentive drives air carrier participation beyond 300 wide-body aircraft. Contract guarantees or fixed buys and favorable treatment for expansion buys are the primary incentives. Missile defensive systems should be a requirement

Table 2. CRAF Long-range international planning targets (*Derived from* David Graham, Jerome Bracken, Joseph Dalfonzo, William Fedorochko, and Robert Hilton, *Sustaining the Civil Reserve Air Fleet [CRAF] Program* [Alexandria, VA: Institute for Defense Analyses, May 2003], 2–3, http://handle.dtic.mil/100.2/ADA431033.)

	Stage I	*Stage II*	*Stage III*	*Total Required/ Committed*
Cargo	30	75	120	120/221
Passenger	30	87	136	161/304

Note: All numbers expressed in wide-body equivalents (capacity of one B-747-100).

for participation in these contracts. The air carrier will bear the cost of aircraft modification and operation. It will pass the additional expense back to the government in the negotiated contract price. As stated earlier, this is an over $2 billion per year business for commercial air carriers. Replacing CRAF capability with organic military airlift would cost at least twice as much for the aircraft only, not even accounting for personnel or maintenance.

Insurability will continue to be a problem. One potential change is the insurance industry demanding defensive systems on CRAF-participating aircraft, further reinforcing the government position. Overall, insurance reform will likely be required in the end.

A properly managed program will incur no throughput changes. A relatively small number of defensive-system-equipped aircraft would increase the scheduling challenge associated with any large deployment. The tail number management challenge for commercial carriers would also increase, and the crew management and training concerns would be the same as outlined in option 2.

Essentially, voluntary compliance with a defensive system mandate for long-range international-segment participation does run the risk of a reduction in commercial carrier participation. Federal funding of 300 wide-body equivalents would ensure a minimum participation, but it does not address the current reliance on commercial contract carriers. Contracts that would assure recouping of defensive systems expenditures and increased contract guarantees might help offset any industry uneasiness.

Option 4—Maintain the status quo

Obviously, the cheapest option is maintaining the status quo. But not equipping aircraft with missile defensive systems would place constraints upon DOD use of commercial aircraft. Insurability will continue to be a driving factor of where and when these aircraft may be used. Delays in making airfields secure will drive unacceptable inefficiencies into the overall airlift system, drastically slowing the rate of deployment or resupply.

In a time of true national emergency, the DOD would be unable to take advantage of one of our nation's greatest strengths, global mobility. As stated earlier, a hub and spoke system based upon an intermediate staging base well outside the hostile area means only half the required materiel and personnel will arrive in combat within planned time frames. Our major theater war plans will be at risk.

Other Alternatives

The Vigilant Eagle concept affords some interesting alternatives. According to the FAA, 35 airports manage 72 percent of the air traffic in the United States. Leveraging the necessity to protect 35 airports rather than 6,800 aircraft, Raytheon estimates system procurement costs six times less than the airborne systems. They estimate the over-20-year-lifecycle costs at less than $2 billion to protect all 35 airports.[68]

A portable version of Vigilant Eagle offers similar protection to forward air bases. This is a very cost-effective alternative to even the 300 wide-body option. The greatest weakness in the portable systems is defending the sensor towers. Adequately securing these towers will demand either increased patrolling or a decreased defensive footprint placing all the towers within the secure perimeter of the airfield.

Project Chloe offers potentially the best of all the air- or ground-based solutions. It is capabilities based since a UAS can serve the dual purpose of intelligence, surveillance, and reconnaissance (ISR) while protecting a well-defined geographic area from MANPADS attacks. One UAS operating above 60,000 feet can defend an area the size of Los Angeles County.[69] The concept was 100 percent effective in live fire testing using a manned vehicle operating at 50,000 feet.[70] Though UASs are expensive, the dual-use nature of Project Chloe combined with ready mobility makes this a promising solution for deployed military operations. All aircraft, civilian or military, US or foreign, benefit from the protective umbrella. The ISR capability augments an under-resourced and over-taxed ISR system currently operating in Iraq and Afghanistan.

Within the United States, Chloe is likely more expensive and provides less coverage than the Vigilant Eagle system. Working much like our current Operation Noble Eagle combat air patrols, one cannot patrol all of North America at once. Chloe systems could operate randomly or in areas where the DHS suspects a direct threat. The ISR capability would enhance border and highway security. Nearly 100 percent of the cost will be borne by the already under-resourced DHS. With a flyaway cost of nearly $75 million per UAS capable of operating at the altitudes required, the DHS may not have the resources to purchase an adequate number of these systems to defend a large part of the United States. UASs also require ground personnel: sensor operators, pilots, and maintenance.

Both alternative solutions do not consider the threat to CRAF aircraft operations in a contingency. Most airfields used by the military lie in the interior or southern parts of the United States outside the coverage proposed for these systems. A hybrid system of defensive-system-equipped aircraft and the alternative solutions is the only way to guarantee full protection for the CRAF mission within the United States.

Conclusion

One of the United States' greatest military advantages is rapid global mobility. No nation in the world can match our ability to project power. The cornerstone of the power-projection capability is military airlift. Military airlift is responsive, flexible, and uniquely capable of operating in a hostile environment. However, current planning for major theater war demands commercial aircraft, specifically the CRAF, augmentation for nearly 40 percent of our cargo movement needs and nearly all of our passenger movements. We will continue to rely upon the CRAF and commercial contracts indefinitely.

Though MANPADSs are widely proliferated, evidence shows the threat to routine commercial airliner operations is low. There has never been a MANPADS attack in the United States on any aircraft, civil or military. DHS has a multilayered protection system in place that works. Likewise, 35 MANPADS attacks and 640 deaths globally pale in comparison to the 1,223 fatal airliner hull-loss accidents and over 32,000 deaths globally in the same period. On average, 42 civil airliners and over 1,100 passengers are lost every year.[71] These numbers do not prevent travelers from filling airliners every day. Estimates of the fiscal losses due to a successful MANPADS attack on commercial aviation presented here are valid only for an attack on American soil. However, there is a very real threat to CRAF and commercial aircraft operating in a hostile environment supporting military operations.

Given the continued reliance on commercial aircraft for military support and the very real threat involved with military operations, the CRAF requires missile defensive systems. Option 3 provides the most responsible solution, placing the fiscal burden in the appropriate places. The DOD should rapidly equip 300 wide-body equivalent aircraft with defensive systems. Furthermore, the US Transportation Command and the US Department of Transportation should modify existing contracts to allow higher rates in order to recoup the cost of CRAF-participating air carriers voluntarily equipping aircraft in the long-range international segment beyond the 300-aircraft goal.

The optimal CRAF solution includes the DOD taking over and further developing Project Chloe for use in a contingency environment. Chloe is easily deployable, capabilities based, and defends all aircraft under its umbrella. Project Chloe offers the greatest promise of all the options discussed.

The best solution for US commercial air traffic operations is Vigilant Eagle. For only a fraction of the cost, the DHS can provide protection to the majority of air traffic operations in the United States with this system. It is automatic, unmanned, and reliable.

Positive action is necessary now to prevent replaying the scenario experienced by the DHL A300 crew described at the beginning of this paper. Without visionary and creative defensive solutions, one man walking around in the desert with an inexpensive, easy-to-procure rocket system can unhinge our entire rapid global mobility system. Defend the CRAF now!

Notes

(All notes appear in shortened form. For full details, see the appropriate entry in the bibliography.)

1. Hughes and Dornheim, "DHL/EAT Crew Lands A300."
2. See Hughes and Dornheim, "DHL/EAT Crew Lands A300"; Bolkom and Elias, *Homeland Security*, 10–11; and US House, *Commercial Aviation*

MANPADS Defense Act of 2004, *Civil Reserve Air Fleet Missile Defense Pilot Program Act of 2007*, and *Civil Reserve Air Fleet Missile Defense Pilot Program Act of 2009*.

3. *Issues Regarding the Current and Future Use*, 1.
4. Graham et al., *Sustaining the Civil Reserve Air Fleet (CRAF)*, 3.
5. US Department of Transportation (US DOT), "Civil Reserve Air Fleet."
6. Joint Publication (JP) 4-01, III-3.
7. US DOT, "Civil Reserve Air Fleet."
8. JP 4-01, III-3.
9. US DOT, "Civil Reserve Air Fleet."
10. Ibid.
11. JP 4-01, III-4.
12. Ibid.
13. US DOT, "Civil Reserve Air Fleet."
14. Air Mobility Command (AMC), *U.S. Air Force Fact Sheet*.
15. Schauber, *Impact of Foreign Ownership*, 4.
16. *Moving U.S. Forces*, 85.
17. Matthews and Holt, *So Many, So Much, So Far, So Fast*, 40–41, 260.
18. Chenowith, *Civil Reserve Air Fleet*, 17; and Matthews and Holt, *So Many, So Much, So Far, So Fast*, 48.
19. Matthews and Holt, *So Many, So Much, So Far, So Fast*, 49–50.
20. Ibid., 48–49.
21. Ibid., 48.
22. *Issues Regarding the Current and Future Use*, 5–6.
23. Fontenot, Degen, and Tohn, *On Point*, chap. 2.
24. Rolfsen, "Audit."
25. Buxbaum, "From Factory to Foxhole."
26. Downing, "The Mobility Air Forces," 42.
27. Ibid., 42–43.
28. Herron, "Future Airlift Requirements," 5.
29. Banholzer, "The Civil Reserve Air Fleet"; and Buxbaum, "From Factory to Foxhole."
30. Banholzer, "The Civil Reserve Air Fleet," 17.
31. Bolkom and Elias, *Homeland Security*, 3–4.
32. Chow et al., *Protecting Commercial Aviation*, 4; and Kuperman, "The Stinger Missile," 254.
33. Bolkom, Elias, and Feickert, "MANPADS Threat."
34. Bolkom and Elias, *Homeland Security*, 4.
35. Bolkom, Elias, and Feickert, "MANPADS Threat."
36. Thompson, "MANPADS"; and Bolkom and Elias, *Homeland Security*, 7.
37. Bolkom and Elias, *Homeland Security*, 8.
38. Ibid.
39. US House, *Commercial Airline Missile Defense Act*.
40. US House, *Commercial Aviation MANPADS Defense Act of 2004*.
41. US House, *Civil Reserve Air Fleet Missile Defense Pilot Program Act of 2007*.
42. US House, *Civil Reserve Air Fleet Missile Defense Pilot Program Act of 2009*.
43. Bolkom and Elias, *Homeland Security*, 22–23.
44. Chow et al., *Protecting Commercial Aviation*, 7–10.

45. Ibid., 14.

46. Ibid.

47. Ibid.

48. Ibid.

49. Ibid.

50. Thompson, "MANPADS."

51. Duffin, "Landing in Baghdad."

52. Chow et al., *Protecting Commercial Aviation*, 14.

53. Richardson, "Counter MANPADS," 16; Northrop Grumman, "Guardian"; Goodman, "DHS Demos Airliner Protection Concept," 17; and Raytheon Corporation, "Vigilant Eagle Airport Protection System."

54. Richardson, "Counter MANPADS," 16; and Northrop Grumman, "Guardian."

55. Goodman, "DHS Demos Airliner Protection Concept," 17.

56. Raytheon Corporation, "Vigilant Eagle Airport Protection System."

57. Chow et al., *Protecting Commercial Aviation*, 15.

58. Federal Aviation Administration (FAA), "Fact Sheet."

59. Chow et al., *Protecting Commercial Aviation*, 14.

60. FAA, *FAA Aerospace Forecast*, 19.

61. Chow et al., *Protecting Commercial Aviation*, 24–25.

62. Ibid., 26–27.

63. Ibid., 29.

64. International Federation of Air Line Pilots' Associations, *IFALPA Security Bulletin*.

65. Richardson, "Counter MANPADS," 16; and Chow et al., *Protecting Commercial Aviation*, 24–29.

66. Ibid.

67. Banholzer, "The Civil Reserve Air Fleet," 9.

68. Raytheon Corporation, "Vigilant Eagle Airport Protection System."

69. Barrie, "Eye in the Sky."

70. Goodman, "DHS Demos Airliner Protection Concept," 17.

71. Aviation Safety Network, "Fatal Airliner Hull-Loss Accidents."

Appendices

Appendix A

CRAF Monthly Allocations - June 2008

June | OFFICE OF INTELLIGENCE, SECURITY, AND EMERGENCY RESPONSE | Enclosure 1

CIVIL RESERVE AIR FLEET (CRAF) MONTHLY ALLOCATIONS

INTERNATIONAL LONG-RANGE PASSENGER (ILP)

ILP Se	AAL	AMT	COA	DAL	HAL	NAO	NWA	OAE	RYN	UAL	USA	WOA	TOTAL
A-300 Series													0
A-330 Series							28				9		37
DC-10-30								8				2	10
B-747-200							2						2
B-747-400							16			30			46
B-757	118		41			5	10	2	3	29	5		213
B-767	11		10						1				22
B-767	55		10	26		5				23			119
B-767-400				21									21
B-777	47			8						52			107
L1011 Series													0
MD-11												5	5
TOTAL	231	0	61	55	0	10	56	10	4	134	14	7	582

INTERNATIONAL SHORT-RANGE PASSENGER (ISP)

ISP Se	AAL	ASA	AMT	BSK	CCP	COA	DAL	GWY	HAL	JBU	NWA	RYN	SCX	SWG	SWI	UAL	TOTA
A-300	30																30
A-320-200										30							30
B-727-200/B					0												0
B-737 Series		24		7									4				35
B-757-200							73										73
B-757-300											16						16
B-767-300 Series									11								11
MD-80	50																50
TOTAL	80	24	0	7	0	0	73	0	11	30	16	0	4	0	0	0	245

INTERNATIONAL LONG-RANGE CARGO (ILC)

ILC Se	ABX	APW	ATN	CKS	DAL	DHL	EIA	FDX	GCO	GTI	MUA	NWA	PAC	SOO	TDX	UPS	WOA	TOTAL
DC-8-62 CB			1															3
DC-8-	0	2																2
DC-8-70F Series			10			8					3							21
DC-10-10C/F								13										13
DC-10-30F		4							7									11
B-747-100F				6			4									2		12
B-747-200F				12			9			13		13	1	15	0	3		66
B-747-300F										1				1				2
B-747-400F										11			6					17
B-767	16	1																17
B-767-300																		0
B-767-400ER																4		4
L-1011-200F																		0
MD-10/11F-CF								127	4							9	6	146
TOTAL	16	7	11	10	0	8	13	146	11	25	3	13	7	16	0	16	6	312

INTERNATIONAL SHORT-RANGE CARGO (ISC)

ISC Se	ABX	DHL	EIA	LYC	NAC	XNA	TOTAL
A-300-B4F		6					6
B-727-100F							0
B-727-200F		3					3
B-737-200					1		1
B767-2	0						0
DC-8-	0						0
DC-9-33F							0
L-100-30				1			1
TOTAL	0	9	0	1	1	0	11

NATIONAL- DOMESTIC (DOM)

DOM	FFT	MEP	SWA	TRS	TOTAL
A-319	3				3
A-320-200					0
B-737-300					0
B-737-700				3	3
B-757-200			29		29
MD-80 Series		1			1
TOTAL	3	1	29	3	36

NATIONAL-ALASKA (AAC)

AAC S	LYC	NAC	TOTAL
DC-6 Series		2	2
L-100-	2		2
TOTAL	2	2	4

AEROMEDICAL (AERO)

AERO Segment	AAL	DAL	UAL	USA	TOTAL
B-767-200ER				6	6
B-767-300DR			4		4
B-767-300ER		32	8		40
TOTAL	0	32	12	6	50

CARRIER LEGEND

AAL - AMERICAN AIRLINES
ABX - ABX AIR
APW - ARROW AIR
ASA - ALASKA AIRLINES
ATN - AIR TRANSPORT INTL
BSK - MIAMI AIR INT'L
CCP - CHAMPION AIR**
CKS - KALITTA AIR
CKS - KALITTA AIR
COA - CONTINENTAL
DAL - DELTA AIRLINES
DHL - DHL AIRWAYS
EIA - EVERGREEN
FDX - FEDERAL EXPRESS
FFT - FRONTIER AIRLINES
GCO - GEMINI AIR CARGO
GTI - ATLAS AIR
GWY - USA 3000 AIRLINES
HAL - HAWAIIAN AIRLINES
JBU- JET BLUE
LYC - LYNDEN AIR CARGO
MEP- MIDWEST AIRLINES
MUA-MURRAY AIR
NAC - NORTHERN AIR CARGO
NAO - NORTH AMERICAN AIRLIN
NWA- NORTHWEST
OAE-OMNI AIR INTERNATIONAL
PAC - POLAR AIR CARGO
RYN - RYAN INTNL AIRLINES
SCX - SUN COUNTRY AIRLINES
SOO - SOUTHERN AIR
SWA - SOUTHWEST
SWI - SUNWORLD INTERNATIONAL
TDX - TRADEWINDS AIRLINES
UAL - UNITED AIRLINES
UPS - UNITED PARCEL
USA - U.S. AIRWAYS
WOA - WORLD
XNA - EXPRESS NET

NEW CARRIER in BOLD ** CARRIER DROPPED OUT

U.S. DOT, Office of the Secretary of Transportation

SUMMARY

	Past Mo April	Change	Current Mo June
ILP	582		582
ILC	316	-4	312
ISP	240	5	245
ISC	11		11
DOM	36		36
ACC	4		4
AERO	50		50
TOTA	1239	1	1240

Appendix B

Non-State Groups with Shoulder-Fired Surface-to-Air Missile Systems, 1996–2001

Adapted from Christopher Bolkom and Bartholomew Elias, *Homeland Security: Protecting Airliners from Terrorist Missiles* (Washington, DC: Congressional Research Service, Library of Congress, 16 February 2006), 5.

Armed Islamic group	Algeria	Stinger (c)
Chechen rebels	Chechnya, Russia	SA-7 (c), Blowpipe (r)
Democratic Republic of the Congo rebel forces	Democratic Republic of the Congo	SA-16 (r)
Harkat ul-Ansar	Kashmir	SA-7 (c)
Hezbullah	Lebanon	SA-7 (c), QW-1 (r), Stinger (r)
Hutu militiamen	Rwanda	Unspecified type (r)
Jamaat e Islami	Afghanistan	SA-7 (c), SA-14 (c)
Jumbish-i-Milli	Afghanistan	SA-7 (c)
Khmer Rouge	Thailand/Cambodia	Unspecified type (r)
Kosovo Liberation Army	Kosovo	SA-7 (r)
Kurdistan Workers Party	Turkey	SA-7 (c), Stinger (c)
Liberation Tigers of Tamil Eelam	Sri Lanka	SA-7 (r), SA-14 (r), HN-5 (c)
Oromo Liberation Front	Ethiopia	Unspecified type (r)
Palestinian Authority	Palestinian autonomous areas and Lebanon	SA-7 (r), Stinger (r)
Popular Front for the Liberation of Palestine-General Command	Palestinian autonomous areas and Lebanon	Unspecified type (r)
Provisional Irish Republican Army	Northern Ireland	SA-7 (c)
Revolutionary Armed Forces of Colombia	Colombia	SA-7 (r), SA-14 (r), SA-16 (r), Redeye (r), Stinger (r)
Rwanda Patriotic Front	Rwanda	SA-7 (r), SA-16 (r)
Somali National Alliance	Somalia	Unspecified types (r)
Al Qaeda/Taliban	Afghanistan	SA-series (c), Stinger (c), Blowpipe (c)
National Liberation Army	Colombia	Stinger (r), Unspecified types (r)
National Liberation Army	Macedonia	SA-18 (c)
National Union for the Total Independence of Angola	Angola	SA-7 (c), SA-14 (r), SA-16 (r), Stinger (c)
United Wa State Army	Myanmar	SA-7 (c), HN-5N (c)
United Somali Congress-Somali Salvation Alliance	Somalia	Unspecified types (r)

Note: (c) is possession confirmed through intelligence sources or actual events; (r) is reported but not confirmed.

Appendix C

MANPAD Attacks against Large Civilian Turbojet Aircraft (1978–Present)

Adapted from Christopher Bolkom and Bartholomew Elias, *Homeland Security: Protecting Airliners from Terrorist Missiles* (Washington, DC: Congressional Research Service, Library of Congress, 16 February 2006), 9.

Date	*Location*	*Aircraft*	*Operator*	*Outcome*
8 November 1983	Angola	Boeing 737	Angolan Airlines (TAAG)	Catastrophic: 130 fatalities of 130 people on board.
9 February 1984	Angola	Boeing 737	Angolan Airlines (TAAG)	Hull Loss: aircraft overran runway on landing after being struck by a missile at 8,000 ft. during climb out. No fatalities with 130 on board.
21 September 1984	Afghanistan	DC-10	Ariana Afghan Airlines	Substantial Damage: aircraft was damaged by the missile, including damage to two hydraulic systems, but landed without further damage. No fatalities.
10 October 1998	Democratic Republic of Congo	Boeing 727	Congo Airlines	Catastrophic: 41 fatalities of 41 people on board.
28 November 2002	Kenya	Boeing 757	Arkia Israeli Airlines	Miss: two SA-7s were fired at the aircraft during climb out, but missed. No fatalities.
22 November 2004	Iraq	Airbus A300	DHL Cargo	Hull Loss: aircraft wing struck by missile departing Baghdad. Aircraft suffered a complete loss of hydraulic power and departed the runway during an emergency landing.

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