Air Line Pilots Association International

WHITE PAPER:

Recommendations for Countermeasures to Man-Portable Air Defense Systems (MANPADS)

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Recommendations for Countermeasures to Man-Portable Air Defense Systems (MANPADS)

The threat to airliners from shoulder-fired anti-aircraft missiles (MANPADS) is real, but the actual risk of a catastrophic hit on a transport category airplane is probably lower than commonly thought. Other standoff weapons can pose a threat equal to or greater than MANPADS, particularly during ground operations.

The Air Line Pilots Association, International (ALPA), is the world's largest airline pilot union, representing more than 55,000 pilots who fly passengers and cargo for 40 airlines in the United States and Canada. ALPA first recognized the threat that shoulder-fired anti-aircraft missiles (MANPADS) pose to the airline industry shortly after the Afghan/Soviet conflict that spanned the decade between 1979 and 1989. ALPA was one of the first organizations to announce and actively promote its concern about this emerging threat, and to convey that concern to government and law enforcement agencies. To learn more about ALPA, visit the Association's website, www.alpa.org.

Executive summary

The threat to airliners from shoulder-fired anti-aircraft missiles, also called Man-Portable Air Defense Systems (MANPADS), is real, but the actual risk of a catastrophic hit on a transport category airplane is probably lower than commonly thought. Other standoff weapons can pose a threat equal to or greater than MANPADS, particularly during ground operations.

Counter-MANPADS (C-MANPADS) systems currently being evaluated for possible airline use are expensive, require a lot of maintenance, may prove incompatible with real-world airline operations, and will not provide a defense against other standoff weapons.

Aircraft can be "hardened" against MANPADS attacks by making them less susceptible to loss of flight control systems.

A propulsion-controlled aircraft (PCA) system can be used to safely fly and land an airliner equipped with a flight management system (FMS) and full-authority digital engine controls (FADEC) whose flight controls have been damaged or incapacitated.

While ALPA believes that the Department of Homeland Security should continue its current C-MANPADS test program, the Association strongly supports developing PCA systems. ALPA also believes that renewed focus should be placed on finding and disabling the "man" in the MANPADS threat.

Because the MANPADS threat to airlines is a threat to U.S. national security, if the U.S. mandates that airliners be equipped with C-MANPADS, the government should bear the cost of procuring and maintaining these systems.

The TSA and FAA have not provided flight crewmembers with procedural guidance regarding how to respond to a suspected or confirmed MANPADS launch, nor explained their plan to manage airspace threatened by a MANPADS attack and the national airspace system (NAS) in general in such circumstances. ALPA believes that the TSA and FAA should remedy these shortcomings.

Recommendations for Countermeasures to Man-Portable Air Defense Systems (MANPADS)

U.S. Secretary of State Condoleezza Rice and Russian Defense Minister Sergey Ivanov shake hands after signing the Unted States-Russia Arrangement on Cooperation in Enhancing Control of Man-Portable Air Defense Systems in Bratislava, Slovakia, on February 24, 2005.

Recommendation

➢ **Prevention**

1. The U.S. government should continue to deploy layered countermeasures such as intelligence-gathering efforts, surveillance, disruption of terrorist plans, and non-proliferation measures to counter all types of standoff threats, including MANPADS. Emphasis should be placed on finding and disabling the "man" in the MANPADS threat.
2. Airports, municipalities, and law enforcement organizations should work to prevent attacks involving MANPADS and other types of standoff weapons by finding likely places of attack and keeping areas around major airports under surveillance.
3. The public should be informed of measures that government and industry are taking to counter MANPADS. The public also should be enlisted in deterring terrorists by developing "airport watch" programs as currently used by a number of U.S. and non-U.S. airport authorities (e.g., in Canada and the United Kingdom).

➢ **Defense**

1. DHS should proceed with its test program for existing C-MANPADS technologies with the active involvement of ALPA and other affected stakeholders.
2. DHS should continue its R&D program to identify advanced C-MANPADS technologies that are highly effective, have low acquisition and maintenance costs, and create minimum aerodynamic drag.
3. Airliners should be made less susceptible to loss of flight control systems through aircraft hardening and by engineering security features (such as PCA systems and hydraulic fuses) into future aircraft designs.
4. If C-MANPADS are mandated for passenger and cargo airliners, the U.S. government should pay for the systems and for installing and maintaining them. Such systems should be fully automated and require no intervention by flight crews to function properly.
5. The TSA and FAA should establish clearly defined procedures for flight crewmember response to a MANPADS threat and define plans to manage air traffic in threatened airspace.

➢ **Response**

1. The U.S. government should continue to test aircraft vulnerability to MANPADS attacks and provide the results of its research to manufacturers for hardening existing and future airliners.

These improved systems possess all-aspect capability that allows them to acquire and attack an approaching or receding airborne target that has a minimal heat signature.

2. Airlines should develop and provide a flight training curriculum that instructs flight crews on how to respond to a MANPADS attack, alternate airport considerations in the event of an actual strike, and emergency flight procedures to use, particularly in those cases in which flight control by conventional means is lost or impaired.
3. ALPA strongly supports developing propulsion-controlled aircraft (PCA) systems as appropriate.
4. Government and industry should develop a crisis management plan to provide guidance for safely and securely operating the national airspace system after a MANPADS attack.

Background

For purposes of this paper, MANPADS are defined as shoulder-fired, anti-aircraft missiles. They are lightweight (about 35 pounds) and relatively easy to use with adequate training.

There are numerous types of MANPADS, many derived from the Soviet-manufactured SA-7 Grail (a Strela-2 system missile with a range of 2.4 nm/4,400 meters) that first entered military service in 1968. Early MANPADS infrared (IR) homing technology allowed only limited rear-aspect acquisition and generally required a shooter to engage aircraft moving away from his/her position.

Two other systems developed by the former Soviet Union, the Strela-3 (SA-14) with a range of 2.9 nm/5,500 meters, and the Igla system (which includes the SA-16 Gimlet and SA-18 Grouse, both with an effective range of 2.8 nm/5,200 meters, significantly improve the performance of MANPADS. These improved systems possess all-aspect capability that allows them to acquire and attack an approaching or receding airborne target that has a minimal heat signature. Both of these systems are also equipped with a larger warhead to increase lethality and employ improved IR seekers designed to resist deception by heat-generating, countermeasure flares.

In addition to the prevalent Soviet/Russian technology, other systems manufactured by the Chinese (HN-5 Vanguard, QW-1, QW-2, and FN-6), British (Blowpipe, Javelin, Sunburst, and Starstreak), Swedish (RBS-70 and Bolide), French (Mistral), and the United States (FIM-43 Redeye, and FIM-92 Stinger) are also reported to be available from global black market sources. Of these systems, the U.S. FIM-92 Stinger-Reprogrammable Micro Processor (RMP), manufactured by Raytheon, is considered the most advanced shoulder-launched missile and is capable of bringing down jet fighters and helicopters equipped with first-generation countermeasures. In addition to IR homing missiles, a number of countries are known to have produced or imported laser-beam-riding missiles that are invulnerable to aircraft-mounted anti-missile systems.

Recommendations for Countermeasures to Man-Portable Air Defense Systems (MANPADS)

According to a U.S. GAO report issued in 2004, of the estimated one million MANPADS missiles produced, between 500,000 and 750,000 are believed to remain in the global inventory worldwide. Estimates put approximately 1 percent of that number, or 5,000 to 7,500, as being outside government control and possibly available on the black market. The U.S. Department of State's Office of Weapons Removal and Abatement, however, has met with some success in keeping these weapon systems out of terrorists' hands.

Although MANPADS' effectiveness is somewhat limited by their relatively small explosive charge, short range, and altitude ceiling, they are maneuverable and can accelerate to speeds exceeding 1.5 mach. Passenger and cargo airliners attacked within the effective range and altitude of a MANPADS cannot outmaneuver or outrun the missile.

ALPA first recognized the MANPADS threat to the airline industry shortly after the Afghan/Soviet conflict that spanned the decade between 1979 and 1989. The lack of accountability for U.S.-supplied Stinger-type missiles and subsequent black market availability of those missiles gave terrorists the potential ability to effectively attack aircraft anywhere in the world. MANPADS provide the terrorist with a desirable "shoot and scoot" capability. ALPA was one of the first organizations to announce and actively promote its concern about this emerging threat, and to convey that concern to government and law enforcement agencies.

Awareness of a MANPADS threat to the airline industry increased dramatically after the attacks against the New York World Trade Center and the Pentagon on Sept. 11, 2001, and the attack against a chartered airliner as it departed Mombasa, Kenya, in 2002. Poor stockpile security, battlefield losses, and corruption and disorder after regime change have enabled growing terrorist regimes and insurgents to acquire MANPADS. Perhaps the greatest threat to efforts to contain MANPADS is the collapse of governments and sudden growth of non-state actors and their ability to acquire these weapon systems.

Fortunately, as of 2007, all MANPADS attacks on airliners have occurred in war zones or regions of active conflict and terrorism. The United States, however, remains at risk because of its current global aviation exposure. As a result, the potential MANPADS threat to airline operations is very real.

According to varying open-source statistics, between 30 and 60 aircraft incidents involving MANPADS have been reported in the last 20 years. Most of these events involved piston, turboprop, or corporate jet airplanes and helicopters in areas of conflict (e.g., Afghanistan, Angola, Nicaragua, Somalia, Sudan, the former Yugoslavia, and the former Soviet Union). According to some publications, several successful hits from these missiles have resulted in 25 downed aircraft and an estimated 600 deaths. It is noteworthy that a majority of these attacks were conducted against propeller-driven airplanes and that six of the seven transport category airplanes struck by MANPADS survived the attack.

It is axiomatic that terrorist organizations such as al-Qaeda possess the motivation and intent to attack airliners. This was demonstrated unequivocally on Sept. 11, 2001, and has been confirmed by additional actions both before and after that date.

How real is the threat?

One significant concern related to the issue of MANPADS countermeasures is determining the probability of an attack on a U.S. airliner. With that being said, ALPA does not have the resources to determine the actual threat that MANPADS pose to airliners. The Association must therefore rely on the capabilities of government and military experts to make such a determination.

Some general observations can be made, however, that are useful in placing the question in perspective. Risk is often defined as a multiple of three variables: opportunity, capability, and intent. The weaker each of these variables is, the less likely that the threat will be realized.

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Whether terrorists are motivated to attack using MANPADS is a more specific but necessary question to pose. Given that other types of weapons are available—weapons less complicated, less costly, equally lethal, and requiring less training—are MANPADS the terrorists' weapons of choice? The 9/11 suicide terrorists used only unsophisticated edged weapons and bomb threats to hijack airliners and destroy the World Trade Center. However, the fact remains that MANPADS have been used against aircraft by terrorist organizations since 2001.

The ability of terrorists to successfully launch a MANPADS attack depends on numerous variables such as quality of training, type and condition of equipment, weather, and the target aircraft's IR signature and location with respect to the shooter. Based upon the demonstrated failure of MANPADS to shoot down an Israeli Arkia Airlines B-757 charter jet departing from Mombasa, Kenya, in 2002 and a DHL A300 freighter departing from Baghdad, Iraq, in 2003, the ability of terrorists to consistently destroy a transport-size airplane remains questionable. However, there have been numerous successful MANPADS attacks, including the highly publicized shoot-down of a Falcon 50 transporting the presidents of Rwanda and Burundi in 1994 and a Congo Airlines B-727 in 1998. More recently, terrorists successfully shot down a Belarusian IL-76 airplane departing from Mogadishu, Somalia, in March 2007.

The opportunity to currently attack airliners in the United States with MANPADS appears thus far to be limited. U.S. government agency representatives have reported that no *known,* illegally obtained MANPADS are within the nation's borders. Furthermore, law enforcement agencies have thwarted several illegal efforts to buy black-market shoulder-fired missiles within the country. This does not, however, guarantee that no such illegal weapons are present. As noted earlier, perhaps thousands of older-generation (and perhaps hundreds

of newer model) MANPADS are available on the black market. Although attempts to smuggle these weapons into the United States appear to have been unsuccessful thus far, it is reasonable to presume that such attempts will continue to be made.

It is important to note that MANPADS represent only one of the several threats that may be present during the taxi, takeoff, and landing phases of flight. Standoff weapons such as mortars and rocket-propelled grenades, as well as large-caliber rifles using incendiary bullets and improvised explosives smuggled aboard by passengers or ground staff, can destroy aircraft. When compared to shoulder-fired MANPADS, many of these devices are far less complicated, relatively inexpensive, easily obtainable, and equally destructive. Furthermore, counter-MANPADS (C-MANPADS) technology will not thwart these types of standoff weapons.

Types of MANPADS countermeasures

C-MANPADS technology was originally developed by the military to counter the airborne IR missile threat to large bombers. This technology later became known as Large Aircraft Infrared Countermeasures (LAIRCM). Unfortunately, airborne countermeasure technologies developed for military or other specialized purposes have not been shown to be compatible with commercial passenger and cargo airline operations. However, a Department of Homeland Security (DHS) effort began in 2004 to develop, design, test, and evaluate an anti-missile system for deployment on airliners.
The DHS hopes to leverage the existing military investment in C-MANPADS technology to develop a cost-effective system tailored to protect civil airliners.

One technology analyzed for potential airline use is the Directed Infrared Countermeasure (DIRCM), an IR device that jams missile guidance systems. However, DIRCM technology is somewhat complicated, a challenge to maintain, and may not meet current airline operational requirements, thus necessitating significant reengineering for airline operations. While the military services, with their robust maintenance and logistical infrastructure, can maintain these systems, DIRCM technology will likely prove incompatible with airlines whose airplanes operate 10-12 hours per day. The cost of training, ground support equipment, supplies, and logistics support at airports across the nation makes DIRCM a questionable candidate for airline use. Estimates put the potential cost of integrating this system into airline operations at $5-$10 billion per year.

A more sophisticated military LAIRCM that employs DIRCM technologies is in development, and efforts are being made to modify it for airline use. DIRCM/LAIRCM systems defeat missile guidance systems by directing a high-intensity modulating laser beam onto the missile seeker head. However, the same extensive maintenance requirements associated with the older-generation

DIRCM systems also currently limit deployment of DIRCM/LAIRCM systems primarily to military and heads-of-state aircraft.

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In order to be a viable security tool for airlines, C-MANPADS must be reliable, operate automatically without crewmember involvement (because of the short time between MANPADS launch and impact), and be affordable. The unit cost established by the DHS is $1 million per aircraft for the 1,000th system delivered. Current DHS vendors Northrop Grumman and BAE Systems (contracted to develop C-MANPADS for airlines) claim their respective proposed systems are within the DHS cost target and "well below" the operational cost target of less than $500 per takeoff and landing.

Current costs for aircraft-mounted C-MANPADS range between $1.3 and $3 million per aircraft. Northrop Grumman has estimated that its system would cost $1.9 million per unit when installed on a 300-aircraft fleet and predicts the cost would drop to $1 million per unit when installed on a 1,000-aircraft fleet. Northrop Grumman has estimated that the operating and maintenance costs would be $26.50 per hour for a 300-aircraft fleet, and would fall below $13 per hour for 1,000 aircraft.

Israel's Elta and Alliant Techsystems' flare countermeasures will cost approximately $300,000 to $500,000 per aircraft, but face significant controversy in the public and governmental domains. Although very effective when deployed in a package, or "cocktail," of C-MANPADS measures, flares as a sole defense have minimal effect against the latest generation of MANPADS. Significant concerns also exist that dispersed flares that fall to the ground could start fires and generate public panic. These concerns have led to restricted use of this countermeasure system in the United Kingdom.

C-MANPADS operating costs will be driven not only by maintenance considerations, but also by drag and weight penalties. Added drag equates to added fuel consumption, while additional weight amounts to lost payload and revenue, and indirectly increases drag. The DHS has set a weight limit of 1,000 pounds (450 kilograms) and a maximum drag penalty of 1 percent for C-MANPADS. The Northrop Grumman DIRCM system weighs approximately 350 pounds and consists of a canoe-shaped appendage attached to the bottom of the fuselage, plus several sensors located around the aircraft's exterior. BAE Systems, whose C-MANPADS design is integrated into the aircraft fuselage, claims its technology will create less drag and will provide significant fuel savings to airlines when compared with the Northrop Grumman system.

If a C-MANPADS system is selected for installation and deployment, someone will have to decide which of the estimated 4,000 to 6,000 U.S. airliners in daily operation will be equipped. Options may include equipping only those airplanes flying into hostile environments, the 300 wide-body airplanes in the Department of Defense Civil Reserve Air Fleet (CRAF), or the entire U.S. airline fleet.

In January 2004, DHS announced that it had reduced the original list of 24 contractors being considered to just three . . .

Government response to the MANPADS threat

The DHS, in partnership with other federal agencies, is taking an aggressive approach to counter the threat that MANPADS pose to airliners. The DHS Science and Technology (S&T) Directorate is leading the effort through its Aircraft Protection Programs Office and is examining the viability of adapting existing technology from military to airline use.

The DHS C-MANPADS initiative uses a robust and disciplined systems-engineering approach. The essence of the program is to collect information from industry, select the best contractors to perform systems analyses and flight tests, and then devise a plan that will permit modifications of airliners with the least disruption and out-of-service costs to the airline industry. The program team works closely with the Departments of Defense, State, and Treasury as well as with the FAA to provide DHS with technical and managerial expertise, advice, and assistance.

After an aggressive analysis, prototype demonstration, and testing phase, the DHS will recommend to the Administration and the Congress the most viable solutions to defend against MANPADS. In January 2004, DHS announced that it had reduced the original list of 24 contractors being considered to just three—BAE Systems, Northrop Grumman, and United Airlines. In August 2004, the United Airlines team was eliminated, and an 18-month Phase II evaluation commenced with BAE Systems and Northrop Grumman vying for the final contract. Phase III began in March 2006 and centers on an in-service evaluation of the Northrop Grumman and BAE Systems prototypes.

From 2003 until 2006, during Phases I and II, DHS worked closely with aviation industry stakeholders and solicited their input through scheduled, executive-level meetings and briefings. DHS described the program's status and procurement process to all participants during this period. These events provided an additional opportunity for potential contractors to learn more about the DHS C-MANPADS solicitation for private-sector assistance in finding commercial applications for military technologies and provided updates on the project to the stakeholder community.

Emerging Counter-MANPADS ground-based technologies

DHS continues to work closely with the Department of Defense and selected vendors to assess the maturity and effectiveness of relevant, ground-based C-MANPADS technologies, to dedicate appropriate resources to evaluating them, and most important, to determine the suitability of these systems for use in civil aviation.

ALPA's National Security Committee (NSC) participates in C-MANPADS efforts and focuses attention on both airborne and land-based defensive activities.

As part of this effort, the DHS S&T Directorate selected three contractors to receive $7.4 million in combined contract awards to support efforts to counter the threat posed by MANPADS to airliners. Those three contractors and their respective programs are:

- L-3 AVISYS and its Commercial Airliner Protection System (CAPS2)
- Raytheon and its Vigilant Eagle Airport Protection System
- Northrop Grumman Space Technology and its Skyguard System

ALPA response to the MANPADS threat

ALPA's National Security Committee (NSC) participates in C-MANPADS efforts and focuses attention on both airborne and land-based defensive activities. The NSC monitors research and development and current threat activity, provides advice and recommendations to ALPA's members, government, and industry from an operational perspective, and frequently attends staff- and executive-level meetings convened by DHS, TSA, the Department of Defense, and major aircraft manufacturers.

In addition to addressing the technical aspects of C-MANPADS, the NSC has found shortcomings in the DHS/TSA MANPADS alerting system and in FAA procedures for air traffic controllers to use after a suspected MANPADS incident. The TSA and FAA have not published instructional guidance for flight crewmembers on how to respond to a MANPADS warning or incident, nor have these agencies provided any information regarding how they will clear air traffic from threatened airspace. The NSC wants to obtain more information and to assist federal authorities, if requested, to ensure that comprehensive policies and procedures are in place to deal with a potential MANPADS attack.

The NSC also strongly supports protecting all CRAF airliners going into known threat areas from surface-to-air threats to the maximum extent possible with proven and appropriate countermeasure systems.

Aircraft survivability

Past events involving catastrophic aircraft hull damage have shown that a wide-body B-747 and a narrow-body B-737 can sustain heavy fuselage damage without resulting in loss of the airplane. At least two significant and ongoing studies and risk assessment programs under way deal with this subject. One is known as the Large Aircraft Survivability Initiative (LASI), conducted by the U.S. Air Force's 46th Test Wing; the other is being conducted by the Joint Aircraft Survivability Program Office (JASPO).

As previously noted, large transport category airplanes have a high statistical probability of surviving damage sustained from a single MANPADS attack, but survival is not guaranteed.

As previously noted, large transport category airplanes have a high statistical probability of surviving damage sustained from a single MANPADS attack, but survival is not guaranteed. Aeronautical design improvements could be made that would markedly improve the odds of surviving single or multiple missile hits. Airliners could be "hardened" to make them less susceptible to damage and loss of primary flight control systems. Although many newer airliners incorporate improvements such as hydraulic fuse plugs and other enhancements to maintain flight control, redundant backup control systems should be considered to ensure survivability. Engine manufacturers are also encouraged to develop power plants with smaller IR signatures to reduce or eliminate the probability of MANPADS detecting them, and to make engines less susceptible to uncontained failures in the event of a MANPADS strike.

The National Transportation Safety Board (NTSB) recommended in 1990 that the FAA "encourage research and development of backup flight control systems" and "give all possible consideration to the redundancy of, and protection for, power sources for flight and engine controls." NASA has conducted research on propulsion control system technology to be used in the event of flight control damage or incapacitation. One such technology is the Propulsion-Controlled Aircraft (PCA) system, a computer-assisted engine control system that enables a pilot to land an airplane safely when its normal control surfaces such as elevators, rudders, and ailerons are disabled. PCA enables the flight crew to safely fly and land an airplane equipped with a flight management system (FMS) and full-authority digital engine control (FADEC) whose flight control systems have been rendered inoperative. NASA has successfully demonstrated this technology on several types of airplanes, including those in the large transport category.

PCA systems could significantly enhance the ability of an airliner to survive any type of standoff weapon attack, not just one involving MANPADS. This technology would also prove useful after loss of flight controls caused by mechanical failure (e.g., United Airlines Flight 232 in Sioux City, Iowa, in 1989). ALPA fully supports developing, certificating, and installing the PCA system, a solution that could be integrated for a fraction of the cost of installing MANPADS countermeasures.

Airline economics

The airline industry is currently experiencing very difficult times described as "the perfect storm" of high fuel prices, terrorist threats, a war-time environment, and the rise of low-cost airlines that are challenging the so-called "legacy" airlines. As a result, the established hub-and-spoke airlines continue to struggle for survival despite passenger loads that equal or surpass pre-September 11, 2001, levels. ALPA concurs with the Air Transport Association's stance that their member airlines cannot afford the cost of buying and maintaining C-MANPADS systems for their fleets.

Recommendations for Countermeasures to Man-Portable Air Defense Systems (MANPADS)

ALPA fully supports developing, certificating, and installing the PCA system, a solution that could be integrated for a fraction of the cost of installing MANPADS countermeasures.

Conclusions

1. The MANPADS threat is real, but the actual risk of a catastrophic hit on a transport category airplane is probably lower than commonly thought.
2. Other standoff weapons can pose a threat equal to or greater than MANPADS, particularly during ground operations.
3. C-MANPADS technology will not provide defense against other standoff weapons.
4. Aircraft can be "hardened" against MANPADS attacks by making them less susceptible to loss of flight control systems.
5. A PCA system can be used to safely fly and land an FMS- and FADEC-equipped airplane whose flight controls have been damaged or incapacitated.
6. Because the MANPADS threat to airlines is a threat to U.S. national security, the U.S. government should bear the cost of procuring and maintaining C-MANPADS.
7. The TSA and FAA have not provided flight crewmembers with procedural guidance regarding how to respond to a suspected or confirmed MANPADS launch, nor explained their plan to manage airspace threatened by a MANPADS attack and the national airspace system (NAS) in general in such circumstances.