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Threats of MANPADS and Its Counter-Measures

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ABSTRACT

The International air transportation industry provides a vital communication link which brings prosperity to many states in our modern age. This invaluable link has been threatened by terrorism. Airlines have been one of the most attractive targets in the eyes of terrorists for several reasons, including particularly the international and symbolic nature of aviation, and the potential of multi-governmental involvement which can inevitably generate wide publicity. Terrorist attacks against civil aviation have been committed since the earliest days of civil aviation history. The first attack against civil aircraft dates back to the early 1930s. Since then, aircraft hijacking and other forms of attack against air transport operations have become one of the most serious challenges to the safety of flying. In recent years, a new form of threats against civil aviation has appeared. Man-portable air defense systems (MANPADS) in the hands of criminals, terrorists, and other non-state actors pose a serious potential threat to passenger air travel, the commercial aviation industry, and military aircraft around the world. The purpose of this study is to provide some countermeasures against such attacks. In order to foster a better understanding of the problem, an introduction of MANPADS and a brief history of attacks using MANPADS are presented. It also examines the level of threats, trends of attacks using MANPADS and the possible countermeasures to be taken by the international community.

Keywords*: MANPADS, Terrorism, Aviation Terrorism, Aviation Security, Counterterrorism Security.*

1. INTRODUCTION

The International air transportation industry provides a vital communication link which brings prosperity to many states in our modern age. This invaluable link has been threatened by terrorism. Airlines have been one of the most attractive targets in the eyes of terrorists for several reasons, including particularly the international and symbolic nature of aviation, and the potential of multi-governmental involvement which can inevitably generate wide publicity. Terrorist attacks against civil aviation have been committed since the early days of civil aviation history. The first attack against civil aircraft dates back to the early 1930s. Since then, aircraft hijacking and other forms of attack against air transport operations have become one of the most serious challenges to the safety of flying.

While technological advances have produced a remarkable degree of safety in the air transportation systems, unparalleled by any other means of transport, violent attacks against civil aviation have posed a man-made threat for which there are no simple technical solutions. Since terrorists came to the conclusion that aircraft hijacking was complicated and did not guarantee a successful outcome, the last two decades have been marked by a most serious eruption of sabotage bombings. Modern technology used by terrorists has bypassed the ability and resources of airline industries to defeat the sophisticated terrorist. Small amounts of plastic explosive is very difficult to detect, and simple to slip into the luggage of an unsuspected passenger. While this presents a vast danger, the future might be overshadowed by a new threat – terrorist attack using man-portable air defense systems (MANPADS) against civil aviation. What is worse, as Paul Wilkinson pointed out, is the possibility of terrorists using chemical and biological weapons in their attacks on civil aviation. Although neither chemical nor biological weapons have been used by terrorists, who are well aware of the political price they would have to pay, the possibility of their use cannot be ruled out. However, previous experience of attacks using MANPADS demonstrates that such attacks should be considered more seriously as a future threat. Such concerns about possible attacks were heightened after the terrorist attacks of September 11th and an unsuccessful attack by terrorists using MANPADS against an Israeli airliner at an airport in Kenya in November 2002.

The purpose of this study is to provide some countermeasures against such attacks. In order to foster a better understanding of the problem, an introduction of MANPADS and a brief history of attacks using MANPADS are presented. It also examines the level of threats, trends of attacks using MANPADS and the possible countermeasures to be taken by the international community.

2. NATURE AND DEVELOPMENT OF MANPADS

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2.1 Technological Development of MANPADS

With the help of modern technology, significant developments have taken place in weapons systems, creating more opportunities for terrorists in terms of weapons and targets. The rapid absorption of new modern technologies by international community and our growing dependence on them have created many high-value targets, such as nuclear power stations and civil aircraft in flight. Similarly, developments in electronics and microelectronics, and the trend toward miniaturization and simplification have resulted in a greater availability of smaller weapons with longer ranges and more accuracy that are also simpler to operate.

One of the most impressive developments in individual weaponry is shoulder-fired surface-to-air missiles (SAMs), what we call MANPADS, which are lightweight and easy to operate. They can usually be carried and operated by a single man. The US-made Stinger, the British-made Blowpipe and the former Soviet-made SA-7 missiles are examples. These are shoulder-fired, anti-aircraft missiles that have infra-red, heat-seeking sensors in the projectile that guide it to the heat emitted from an aircraft engine. There is no doubt that most of them maintain strict security measures to prevent the outflow of the weapons. However, some states, including Libya, have supplied MANPADS to terrorist organizations [1]. It is clear that in the hands of terrorists these missiles are not likely to be used against military tanks and fighter jet of the air forces. Of particular concern is the prospect of civilian airliners being shot at by MANPADS as they land at or take off from airports [2].

With increased airport security, the possibility of placing explosive devices on civil aircraft is becoming lower, but now the same destructive result can be achieved far more easily by using modern missiles. In this connection, MANPADS in the hands of criminals, terrorists, and other non-state actors pose a serious potential threat to passenger air travel, the commercial aviation industry and military aircraft around the world.

2.2 Standard Specification and History of MANPADS

Man-Portable Air Defense Systems (MANPADS), commonly described as shoulder-fired anti-aircraft missiles, are short range surface-to-air missiles that can be carried and fired by a single individual or carried by several individuals and fired by more than one person acting as a crew.

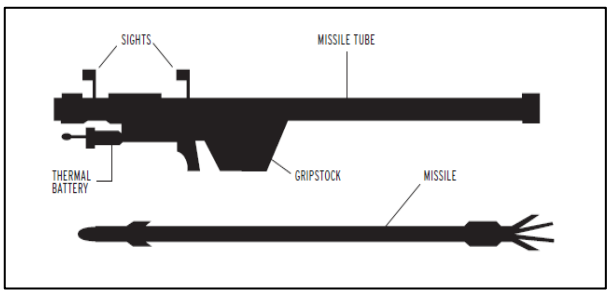

Fig. 1.Typical MANPADS Composition

Most MANPADS consist of: 1) a missile packaged in a tube; 2) a launching mechanism (commonly known as a grip stock); 3) a battery [3].

The tubes have an aiming device, which protect the missile until it has been fired, and are normally disposable. The missiles themselves usually contain the homing device(s) that direct them towards their aerial target. MANPADS (tube with missile within), typically range from about 4 feet to 6 1/2 feet (1.2 to 2 meters) in length and are about 3 inches (72 millimeters) in diameter. Their weight, with launcher, ranges from about 28 pounds to just over 55 pounds (13 to 25 kilograms). They are easy to transport and conceal. Some of the most commonly proliferated MANPADS are about the size and weight of a full golf bag and can easily fit into the trunk of an automobile. There are three main types of MANPADS classified primarily by their guidance systems or "seekers:" 1) Infrared (IR) that hone in on an aircraft's heat source, usually the engine's exhaust plume; 2) Command Line-of-Sight (CLOS) whereby the MANPADS operator visually acquires the target aircraft using a magnified optical sight and then uses radio controls to guide the missile into the aircraft; 3) Laser Beam Riders in which the missile flies along the laser beam and strikes the aircraft where the operator has aimed the laser[3].

Generally MANPADS have a range of up to 8,000 meters and a maximum altitude of around 4,000 meters. Commercial aircraft fly much higher than this while on route and are therefore only exposed to the MANPAD threat during takeoff and landing [4]. MANPADS were designed to be used by legitimate national military forces to protect their troops and facilities. With their relatively short range, MANPADS are regarded as the last missile-based air defense available to protect against aerial attack, to be deployed in tandem with gun-type systems that seek to defeat attacking aircraft by destroying them with a barrage of projectiles. Although superficially similar in appearance, MANPADS should not be confused with rocket-propelled grenades (RPGs). RPGs are also portable and shoulder-fired. However, RPGs are unguided weapons designed primarily to be used against ground targets and are generally ineffective against aircraft, except at very close range. Some RPG attacks on low-flying aircraft have been mistaken for MANPADS attacks.

2.3 Major Types of MANPADS

2.3.1 Blowpipe

The British Blowpipe is designed to defend forward-deployed troops against close-range low-level air attack. To carry out this role effectively, the weapon is compact, light and simple enough to be both carried and operated by a single man. The Blowpipe is entirely self-contained with no external power requirements, and consists of two main components: the missile, sealed within its launching canister, and the aiming unit [5]. The Blowpipe does not rely on infra-red guidance to find its target but rather is guided by an aimer who steers the missile to its target by means of a radio link. It can be brought into action very quickly, and reloading takes just a few seconds. The Blowpipe is 1390 mm long and weighs 11.1 kg. Apart from the advantage of mobility, it can destroy an aircraft flying at an altitude of around 2010 m over a range of 4025 m [6]. The operator lifts the Blowpipe to his shoulder, focuses on the target with the aid of a monocular sight and then initiates the system.

2.3.2 Javelin

The British Javelin is an advanced version of Blowpipe and is designed to deal more effectively with battlefield targets such as combat helicopters, which can launch antitank missiles at ranges of up to 4115 m [7]. Targeting at greater range is aided by the employment of semiautomatic command to line-of-sight guidance, requiring the operator merely to keep the target centered in his sight, rather than to guide the missile. The performance of the Javelin is such that the manufacturer has opted to develop a series of lightweight multiple launchers, of which there are two versions – man-portable with a seated operator and man-portable with a standing operator – to increase its operational flexibility. Both models could be transported easily in an average sized car. The Javelin can hit an aircraft flying at an altitude of around 1980 m over a range of 5485 m [6].

2.3.3 SA-7 Grail

Developed in the early 1960s, the Soviet SA-7 Grail is known in Soviet service terminology as the Strela-2. It is a simple weapon that was used first in combat during the 1967 Six-Day War and later during 1973 Arab-Israel War [8]. It is operated by a two-man team, one of whom carries the firing unit and a missile and the other a second missile. It is tube-mounted and fired from shoulder. This heat-seeking missile has been used effectively against helicopters and low-flying aircraft, despite countermeasures which included the use of decoy flares and deflected helicopter exhaust [9]. The overall length of the weapon 1500 mm and it weighs about 15 kg. A useful, easily handled weapon against low-flying aircraft, it had been adopted by a number of Soviet-backed guerrilla groups and terrorist organizations throughout the world. It has also known that more than 50 states all over the world, including Iran, Lebanon, Libya, Algeria, North Korea and Cuba, are in possession of SA-7 missiles. It was reported that a large number of SA-7s are in the arsenal of the terrorist organizations [10].

2.3.4 SA-14 Gremlin

The Soviet made SA-14 Gremlin was introduced in the mid-1980s as a replacement for the elderly and limited Sa-7 series. Unlike most shoulder-fired MANPADS, this system is an ideal weapon for terrorists. It is only 1300 mm long and weighs 9.9 kg, making it very easy to transport and conceal in a trunk. At the same time it can destroy an aircraft flying at an altitude of around 5500 m over a range of 6000 m [5]. If terrorists were to survey the flight paths near any international airport where aircraft are flying within the range of this system, it would become apparent that an attack could be launched from a very wide geographical area.

2.3.5 Redeye

The US Redeye is a shoulder-fired guided missile system designed to give troops an effective defense against low-flying aircraft. It was the world's first operational infantry-carried MANPADS, and its development commenced in the late 1950s in an effort to provide US infantry units with a man-portable system. It entered into service in 1966[5]. The missile is a very simple first-generation system that is guided to its target by a passive infra-red homing device, which limits its use to pursuit engagements, the missile's guidance system being capable of homing in on the heat from the exhaust emissions of aircraft. To be effective the missile must be able to overtake the pursued aircraft within a range of about 3-4 km which restricts its use to comparatively low-speed targets. The Redeye is only 1219 mm long and the complete missile and its launcher weighs 13 kg [6].

2.3.6 Stinger

The US-made Stinger Missile appeared in the early 1980s as a substitute for the General Dynamics FIM-43 Redeye surface-to-air missile. It is a shoulder-fired guided missile system designed to give solders an effective defense against low-flying aircraft. Advanced propellants were used to ensure that Stinger performance levels would be appreciably higher than those of the Redeye, despite the Stinger's greater weight. One of the most important improvements incorporated into the Stinger is its greater resistance to electronic and other countermeasures [2]. The operator focuses on his target using the system's open sight, initiates the missile functions, identifies the target with the Identification Friend or Foe (IFF) subsystem then launches the missiles. The basic shoulder-launched Stinger provides the United States and its allies with an efficient and man-portable MANPADS. It is reported that this system has also been used by terrorists. The Stinger is 1520 mm long and weighs 13.6 kg including launcher, making it transportable in a small car. It can destroy an aircraft flying at an altitude of around 4800 m over a range of 5030 m [2], [6].

3. THREAT ANALYSIS OF MANPADS

3.1 Current Picture of MANPADS Attacks

The use of MANPADS by terrorists is not new. The following list in the Table1 is a sample of reported incidents involving civilian aircraft. The first reported attempt to use MANPADS against a civilian aircraft was in 1973, in Rome. On 5 September 1973 Italian police arrested five Middle-Eastern terrorists armed with SA-7s. The terrorists had rented an apartment under the flight path to Rome Fuicimino Airport and were planning to shoot down an El Al airliner coming in to land at the airport [2], [8]. This affair proved a considerable embarrassment to Egypt because the SA-7s were later traced back to a batch supplied to it by the former Soviet Union. It is believed that pressure from the Libyan leader, Kaddafi, who was then urging the unification of Egypt and Libya, had led to the Egyptian government supplying some of the missiles to the Libyan military forces. However the SA-7s had been directly rerouted to the terrorists. At the same time this incident also put the Soviet Union in an awkward position because its secrets on the new MANPADS and its policy of the proxy use of surrogate warfare against democratic states were revealed to the West [11]. The plot of the missile attack on El Al derived from an appalling incident on 21 February 1973, when a Libyan B-727 was shot down over the Sinai desert by an Israeli fighter, killing the 108 people onboard. The Libyan people called for vengeance against Israel. Kaddafi also urged the other Arab states to send their warplanes against Israel's major cities and to destroy Israeli airlines wherever they could be found [12].

On 5 January 1974, 220 soldiers and 200 police sealed off five square miles around Heathrow International airport in London after receiving reports that terrorists had smuggled SA-7s into the United Kingdom in the diplomatic pouches of Middle-Eastern embassies and were planning to shoot down an El Al airliner [13]. On 13 January 1975, an attempt by terrorists to shoot down an El Al plane with a missile was shocked to the world. Two terrorists drove their car onto the apron at Orly airport, where they set up a rocket launcher and fired at an El Al airliner which was about to take off for New York with 136 passengers. The first round missed the target thanks to the pilot's evasive action and hit the fuselage of a Yugoslav DC-9 airplane which was waiting nearby to embark passengers for Zagreb. The rocket failed to explode and no serious casualties were reported. After firing again and hitting an administrative building, which caused some damage, the terrorists were escaped by car. Six days later, another dramatic though unsuccessful missile attack was attempted at Orly airport again. It is known that an El Al had been deliberately chosen as a target by Kaddafi in an attempt to avenge the loss of the Libyan airliner shot down by Israel over the Sinai desert [11].

Despite these failures on 25 January 1976, another abortive attempt was carried out by three PFLP terrorists, who were arrested by Kenyan police at Nairobi airport before they had time to fire SA-7 missiles at an El Al aircraft carrying 100 passengers [11].

On 21 September 1984 Afghan counter-revolutionaries fired a surface-to-air missile and hit a DC-10 Ariana Airliner carrying 308 passengers. The explosion tore through the aircraft's left engine, damaging its hydraulic system and a wing containing a fuel tank. The captain of the aircraft, however, managed to land the aircraft safely at Kabul International Airport [14]. Another significant incident took place on 4 April 1985, when a member of Abu Nidal Organization fired an RPG rocket at an Alia airliner as it took off from Athens Airport. Although the rocket did not explode, it left a hole in the fuselage [15].

The catastrophic loss of a civilian aircraft from a suspected MANPADS attack was the October 10, 1998, downing of a Congo Airlines Boeing 727 near Kindu, Democratic Republic of Congo. The aircraft was reportedly shot down by a missile, possibly an SA-7, which struck one of the airplane's engines. Tutsi rebels admitted to the shooting, claiming that they believed the airplane to be carrying military supplies. The final call from the Captain indicated that the aircraft had been hit by a missile and had an engine fire. It was reported that a missile struck the airplane's rear engine. The ensuing crash killed all 41 persons on board [16].

The most recent attempted shooting of a passenger jet was on November 28, 2002, the incident involving an Israeli-registered Boeing 757 aircraft operated by Arkia Israeli Airlines. Two SA-7 missiles were fired at the airplane on departure from Mombasa, Kenya but missed. While the threat of shoulder-fired missiles has long been recognized by aviation security experts, this incident focused the attention of many in Congress and the Bush Administration on this threat and options to mitigate it. Unlike the prior attacks on jet airliners that occurred in war torn areas, the Mombasa attack was clearly a politically motivated attack, believed to have been carried out by terrorists with links to Al Qaeda [17].

MANPADS attacks on civilian aircraft have occurred sporadically over the last three decades. In total there have been around fifty attacks, resulting in the loss of over thirty aircraft and over 800 lives [18].

In the 1970s, attacks occurred in Laos, Cambodia and Vietnam, where various conflicts were taking place. In the 1980s, many attacks occurred around Afghanistan, where MANPADS were in use by Mujahedeen resisting the Soviet invasion or in Saharan Africa, where various conflicts occurred.

Table 1. Statistics on MANPADS Attacks against Civil Aviation (1967-2007)[1]

Flight Phase	Hit	Misses	Crashed
Initial Climb	7	1	6
Climb	9	0	7
Cruise	20	0	15
Descent	4	1	1
Approach	8	1	4
Total	48	3	45

The 1990s saw attacks move to the Middle East and former Soviet satellite states Georgia and Azerbaijan, coincident with the Gulf War and Chechen conflict respectively. Unstable states in Africa such as Angola, Rwanda, Congo and Sudan have been the location of many attacks over the entire time period. By far the highest operational risk of MANPADS attack on aircraft is in war zones or places of conflict, where weapons are much more readily available, and the environment exhibits high levels of confusion, often allowing armed militants to move freely. However as the Mombasa incident shows, attacks can also occur in more peaceful locations.

3.2 Proliferation of MANPADS

The proliferation of portable, shoulder fired surface to air missiles has for many years led to fears that an individual or group would attempt to use such a missile to bring down a large commercial jet airliner. Some 20 countries have produced or have licenses to produce MANPADS or their components. These include Bulgaria, China, Egypt, France, Germany, Greece, Iran, Japan, the Netherlands, North Korea, Pakistan, Poland, Romania, Russia, Serbia, South Korea, Sweden, Turkey, the United Kingdom and the United States [18]. It is estimated that over 1 million MANPADS missiles have been manufactured worldwide since they were first produced in 1950s.

MANPADS are found in the stockpiles of many countries around the world, including those of manufacturing military nations. However, estimating the total number of MANPADS in the global inventory is difficult with precision because the destruction of MANPADS systems—either by warfare, accident or systematic demilitarization—is not always tracked or publicized. Unclassified estimates of the worldwide

[1] This statistics are coming from Australian Government, Ministry of Foreign and Trade, Man-Portable Air Defence Systems (MANPADS): *Countering the Terrorist Threat*, June 2008, p. 11

shoulder-fired SAMs inventory are widely varied. Published estimates on the number of missiles presently being held in international military arsenals range from 350,000[19] to 500,000[20] but disparities among nations in accountability, inventory control, and reporting procedures could make these figures inaccurate. Tracking proliferation to non-state actors is considered even more difficult by many analysts. There are a variety of means that terrorist organizations use to obtain missiles, including theft, black market, international organized crime, arms dealers, and transfers from states willing to supply missiles to terrorists. Often times, the only verification that a non-state actor has a shoulder-fired SAM are when a launcher or fragments from an expended missile are recovered after an attack [21]. As in the case of military arsenals, estimates of shoulder-fired SAMs in terrorist hands vary considerably. Estimates range from 5,000 to 150,000 of various missile types, but most experts agree that the vast majority of them are IR guided and are likely SA-7 derivatives, versions of which are reportedly possessed by at least 56 countries [19]. Some examples attest to the large numbers of these missiles in circulation. As of December 2002, coalition forces in Afghanistan had reportedly captured 5,592 shoulder- fired SAMs from the Taliban and Al Qaeda [22]. Some of these included U.S. Stinger and British Blowpipe and Redeye missiles believed to have been left over from the Afghan-Soviet War. In fact, the United States supplied such missiles to rebel movements (Taliban at that time) in Afghanistan to counter Soviet-sponsored subversion [23]. Shoulder-fired missiles continue to be seized routinely during coalition raids, suggesting that Taliban and Al Qaeda forces operating in and around Afghanistan still have access to an undetermined number of these systems. In Iraq, recent press reports indicate that 4,000 to 5,000 shoulder-fired SAMs may be available to Iraqi insurgent forces[24] Africa, the region where most terrorist attacks with these missiles have occurred, reportedly also has a large quantity of shoulder-fired SAMs left over from Cold War sponsorships and the numerous civil wars of that era.

Currently, around 25 to 30 non-state groups and terrorist groups including Al Qaeda1 have confirmed or reported possession of MANPADS [25].

Table 2. Major Non-State Groups with MANPADS

Group	Location	Missile Type
Armed Islamic Group (GIA)	Algeria	Stinger (c)
Chechen rebels	Chechnya	SA-7 (c), Stinger (c), Blowpipe (r)
Democratic Republic of the Congo (DRC) rebel forces	Democratic Republic of the Congo	SA-16 (r)
Harkat ul-Ansar (HUA)	Kashmir	SA-7 (c)
Hezbollah	Lebanon	SA-7 (c),QW-1 (r), Stinger (r)
Hizbul Mujahedin (HM)	Kashmir	Stinger (r)
Jamaat e Islami	Afghanistan	SA-7 (c), SA-14 (c)
Kosovo Liberation Army(KLA)	Kosovo	SA-7 (r)
Kurdistan Workers Party (PKK)	Turkey	SA-7 (c), Stinger (c)
Liberation Tigers of Tamil Eeelam(LTTE)	Sri Lanka	SA-7 (r), SA-14 (r), Stinger (c)
Popular Front for the Liberation of Palestine-General Command (PFLPGC)	Palestine and Lebanon	Unspecified type (r)
Palestinian Authority (PA)	Palestine and Lebanon	SA-7 (r), Stinger (r)
Provisional Irish Republican Army (PIRA)	Northern Ireland	SA-7 (c)
Revolutionary Armed Forces Of Colombia (FARC)	Colombia	SA-7 (r), SA-4 (r), SA-16 (r), Redeye (r), Stinger (r)
Rwanda Patriotic Front (RPF)	Rwanda	SA-7 (r), SA-16 (r)
Somali National Alliance(SNA)	Somalia	Unspecified types (r)

* (c): Confirmed, (r): Reported

In some cases, it is known that they have obtained the MANPADS through the black market and illegal smuggling. The black market cost of MANPADS can vary widely, ranging from as little as a few hundred dollars, to several thousand dollars, depending on the model and its condition. Table1 depicts major non-state groups believed to possess MANPADS through the 1996-2001 time periods.[2]

4. COUNTER-MEASURES AGAINST MANPADS

Most believe that no single solution exists to effectively mitigate this threat. Instead, a menu of options may be considered, including intelligence gathering; installing infrared (IR) countermeasures on aircraft; modifying flight operations and air traffic control procedures; improving airport and regional security; and strengthening missile non-proliferation efforts.

4.1 Improvement of Intelligence Gathering Capability

In his classic Bean Fat (Art of War), Sun Tzu said ‘Know the Enemy and know yourself, then in a hundred battles you will never be in peril’ [26]. This maxim stresses the importance of intelligence gathering. In other words, good intelligence remains the first line of defense against any kind of hostile attacks. It is true that modern technologies clearly aid terrorists in terms of weapons and targets. However, technology can also be used against terrorists. With the help of computers, Western governments can keep track of terrorist’s organizations and their movements. At the same time, electronic collection methods and signals intelligence afford the possibility of eavesdropping on and intercepting terrorist communications,

[2] Additional groups may have obtained missiles since 2001 but details at the unclassified level are not known.

leading to better pre-directions of their operations. A good example of intelligence gathering by the use of high technology aerial reconnaissance occurred September 1984, when the Provisional IRA spent an estimated 1.5 million pounds in the United States on a massive shipment of seven tons of arms. With the help of an informer about a forthcoming shipment of weapons, including MANPADS, to the Provisional IRA from the United States, the FBI informed British intelligence, who in turn contacted the Irish, and the ship carrying the arms was tracked by a US satellite orbiting 300 km above the earth. The satellite photographed the transfer of the arms to a trawler. Finally, two Irish Navy ships intercepted the trawler and British security forces arrested the crew [25]. This case has shown that intelligence gathering with the help of modern technology can cut off the transfer of MANPADS and other weapons to the hands of terrorists.

Sharing of intelligence about terrorists, their movements, and their planned attacks is an absolute prerequisite for successful interdiction. Governments in every region of the world have been able to use this information to expose the criminal netherworld in which terrorists operate. Undoubtedly, planned attacks have been prevented, and lives have been saved. Effective intelligence exchange allows countries to act preemptively to counter terrorists before they act. In addition, aggressive counter-terrorism intelligence initiatives and stepped-up law enforcement could interdict illegal weapons trafficking. Although thousands of MANPAD missiles may be currently available in the black market, aggressive counter-terrorist intelligence and law-enforcement initiatives could effectively and proactively reduce risks.

4.2 Installation of Counter-MANPADS System

Individual planes could be equipped with defense mechanisms against missile attacks. Many military aircraft and some commercial planes such as El Al, the Israeli airline, have the capacity to use flares and advanced technology to divert incoming missiles. Although military countermeasure systems are quite mature, there have been extremely few examples of civilian aircraft being fitted with such systems. Estimated costs to install an IR countermeasure system on a commercial aircraft would be around US$1 to 3 million dollars per aircraft. Installing a countermeasure system on a commercial aircraft would increase the drag of the airliner due to the addition of a pod or dome or require extensive airframe modifications. Although this drag might seem insignificant, it can, with the added weight of the system, increase the operating costs of an airline through added fuel costs [4]. Although current options for such defense are inordinately expensive given the level of the threat, submitting a request for such technology to the open market could yield less costly and more accessible defense options. The technology for such a defense already exists and effective diversion mechanisms for commercial planes need not be as robust as those for military aircraft. A priority for such defense efforts should be high-threat, high-density airports.

4.3 The Perimeter Guard

For a successful MANPADS attack against aircraft, the firing position has to be located within range of the flight path. A missile's guidance system is such that the weapon has to be fired within a few degree of the flight path if the infra-red guidance is to locate the target. Accordingly, a possible preventive measure would be to prevent terrorists forgetting into a firing position with their missile. Securing an airport perimeter is the matter that can be achieved easily. It is a daunting task and would be very difficult to cut off areas of up to several kilometers wide that lie in the paths of aircraft as they land and take off. This measure is therefore impracticable if not impossible [27]. However patrolling the outer areas of airports in times of stringent security conditions might prevent such attacks. Even in times when no specific threat has been received, it is within the capacity of most states to monitor those strips of land from which a missile could be launched and thus minimize the risk. At the same time, these security operations would deter terrorists from spending vital resources on buying MANPADS given the limited possibilities for their use.

4.4 Monitoring Windows of Vulnerability

Missiles can be detected through well-targeted monitoring. Given the limited range of MANPADS, jetliners are vulnerable only during take-offs and landings and can be fired on only from certain areas. Authorities should focus on these "windows of vulnerability" in airports and monitor unauthorized personnel or utilize sensors to detect MANPAD firing so that timely evasive action can be taken. Ongoing efforts of international communities to survey and identify areas of vulnerability at their airports should be strengthened.

4.5 Pilot Training for Evasive Maneuvering Skills

The potential mitigation technique that we can consider is training flight crews in evasive maneuvers if fired upon by a shoulder-fired SAM. However, this approach would not likely be effective and presents significant risks. Without a missile detection and warning system, it is very difficult for a flight crew to have the indication of a missile launch. Also, large transport category airplanes are generally not maneuverable enough to evade a shoulder-fired SAM. There is also concern that defensive maneuvering of large transport category airplanes could result in a loss of control or structural failure [28]. Consequently most observers concur that evasive maneuvering is not a viable option for mitigating the risk of missile attacks. However, properly trained crews may be able to use other special procedures to evade missile attacks. Successful evasion is a low-cost, near-term solution to the threat. A trained pilot can be effective in evading missiles. Thus, a relatively low-cost and efficient near-term response to the missile threat is to provide pilots and air controllers with training regarding evasion procedures.

4.6 Research and Development on the Counter-MANPADS Technology

Stepped-up research and development for counter-MANPADS capability could substantially lower the missile threat. Robust research and development of high-tech counter-weapons, such as the mobile tactical high-energy laser (MTHEL), could yield effective and cost-efficient means to protect airports and other critical infrastructure from a spectrum of short-range threats [29]. Efforts within the military to

develop such technology are, even now, yielding significant results.

4.7 International Efforts on Counter-Proliferation of MANPADS

International community has been active in promoting efforts to secure global MANPADS stocks and to bolster export controls. Many countries including the United States are also working to promote action to lower the risk of MANPADS attacks against civilian aviation. Due to the transnational nature of MANPADS production and proliferation, a sustained and coordinated international effort is required to address the truly global MANPADS threat. The international approach aims to prevent the proliferation and illegal trade of sophisticated modern MANPADS, and to effectively manage or reduce existing military stockpiles of MANPADS. Current stocks must be stored securely and be well-accounted for. Obsolete stocks should be destroyed to prevent them from falling into the wrong hands. A number of multilateral and regional organizations have taken a proactive approach to the export control and stockpile management of extant MANPADS, and to the destruction of surplus systems. In connection with this effort, on February 24, 2005, U.S. Secretary of State Condoleezza Rice and Russian Minister of Defense Sergey Ivanov signed the "United States-Russia Arrangement on Cooperation in Enhancing Control of Man-Portable Air Defense Systems" in Bratislava, Slovakia to facilitate mutual destruction of obsolete or excess MANPADS, exchange information on controlling MANPADS including improving measures to enhance physical security, and to share information about MANPADS sales and transfers to third countries.

The United Nations General Assembly has also been involved in MANPADS non-proliferation, adopting Australian-sponsored resolutions in 2004, 2006 and 2007 to prevent the illicit transfer of, unauthorized access to and use of MANPADS. APEC agreed on MANPADS declarations at its 2003 and 2005 meetings. The G8 has an action plan for reducing the risk to civilian aviation and the Organization of American States also has MANPADS security and control guidelines. International efforts to curb the illicit spread of MANPADS have also been taken forward through the International Civil Aviation Organization. Similarly, the Leaders' Declaration at the 2003 and 2005 Asia Pacific Economic Cooperation (APEC) meetings have made strong statements about the resolve of the participating states to strengthen joint efforts curb terrorist threats against mass transportation. In particular, the leaders resolved to meet the threat posed by the acquisition and use of MANPADS by terrorist groups. Endorsing the elements identified by the United Nations, the 2003 APEC declaration included a review in 2004 of progress to date [2]. At the 2004 meeting, the APEC Ministerial Meeting noted that they had agreed guidelines on the control of MANPADS. The participating states agreed to work domestically on implementing those guidelines and, as appropriate, to work with United Nations efforts [30].

5. CONCLUSION

The widespread production of MANPADS, the potential for proliferation to terrorist groups and the effectiveness of MANPADS in the hands of non-state actors represent a significant risk to civil aviation. With increased aviation security, the possibility of aircraft hijacking by terrorists is becoming more and more difficult. Consequently it is not difficult to imagine that terrorists will select other means to achieve their aim. Although not many experts have focused on the possibility of attacks using MANPADS, this form of attack must be seriously considered. In addition, international community must take preventive measures against such attacks. MANPADS have been described by the UN as a 'weapon of mass effect', recognizing that a credible threat of a terrorist attack is enough to affect public confidence and willingness to use civilian aviation. Civilian aircraft can be protected from MANPADS attacks using countermeasures. Military aircraft have carried such systems for some time but it is expensive to transfer that technology to civilian aircraft. However, technical countermeasures are only one part of a layered security approach to defeat and deter the threat posed to civil aviation posed by MANPADS. Other measures may include non-proliferation, intelligence gathering, and airport security. In order for air transportation to be freed of the menace of terrorist attack, governments and the civil aviation industry must employ very available method of political statecraft.

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