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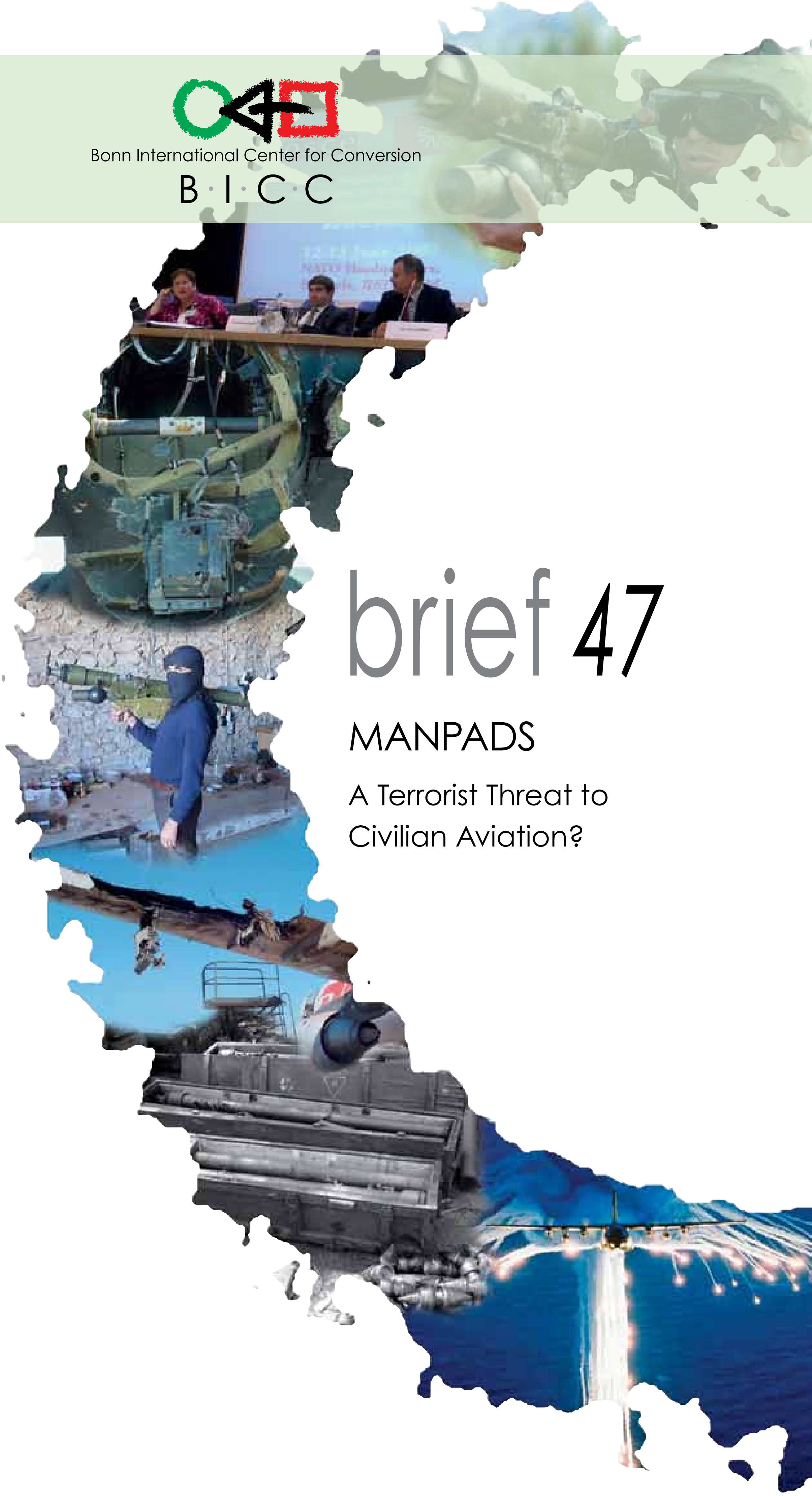

brief 47

MANPADS

A Terrorist Threat to Civilian Aviation?

Contents

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MANPADS

A Terrorist Threat to Civilian Aviation?

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List of acronyms

AA	Anti-Air
AD	Air Defense
ALBI	Air-Launched Ballistic Intercept
APEC	Asia-Pacific Economic Forum
AQIM	Al-Qaida in the Maghreb
ASEAN	Association of Southeast Asian Nations
ATLAS	Advanced Twin Launcher Anti-air Strikes
BCU	Battery Coolant Unit
BICC	Bonn International Center for Conversion
CCD	Charge-Coupled Device
CdS	Cadmium Sulfide
CIS	Commonwealth of Independent States
CLOS	Command to Line-of-Sight
CM	Countermeasures
CPU	Central Processing Unit
CREWPADS	Crew-Portable Air Defense Systems
DIRCM	Directed Infrared Countermeasure
DMZ	Demilitarized Zone
FARC	Fuerzas Armadas Revolucionarias de Colombia (Revolutionary Armed Forces of Colombia)
FMLN	Frente Farabundo Marti para la Liberación Nacional (Farabundo Marti National Liberation Front)
FN	Fei Nu (Flying Crossbow)
FOV	Field of view
FSA	Free Syrian Army
FYR	Former Yugoslav Republic
GOB	Government of Belarus
GUNT	Gouvernement d'Union Nationale de Transition (Transitional Government of National Unity)
HEL	High-Energy Laser
HgCdTe	Mercury Cadmium Telluride
HN	Hong Nu (Red Cherry)
HY	Hong Yang (Red Tassel)
ICAO	International Civil Aviation Organization
ICU	Islamic Courts Union
IFALPA	International Federation of Air Line Pilots' Associations
IFF	Identification Friend or Foe
InSb	Indium Antimonide
IR	Infrared
IRCM	Infrared Countermeasure System
ISAF	International Security Assistance Force
LML	Lightweight Multiple Launcher
LOS	Line of Sight
LTTE	Liberation Tigers of Tamil Eelam
MANPADS	Man-Portable Air Defense Systems
MAWS	Missile Approach Warning System
MBDA	Matra BAe Dynamics Alenia Marconi Systems
MFA	Ministry for Foreign Affairs
mmW	Millimeter Waves
MNLA	Mouvement National de l'Azawad (National Movement for the Liberation of Azawad)
MPLA	Movimento Popular de Libertacao de Angola (People's Movement for the Liberation of Angola)
MTHEL	Mobile Tactical High-Energy Laser
NAMSA	NATO Maintenance and Supply Agency
Nm	Nanometers
NSAG	Non-State Armed Group
NSPA	NATO Support Agency
OAG	Organized Armed Group

OAS	Organization of American States
OOB	Order of Battle
OSCE	Organization for Security and Co-operation in Europe
PbS	Lead Sulfide
PFLP	Popular Front for the Liberation of Palestine
PKK	Partiya Karkeren Kurdistan (Kurdistan Workers' Party)
PLA	People's Liberation Army
PLAAF	PLA Air Force
PLAN	PLA Navy
PLO	Palestine Liberation Organization
PM/WRA	Office of Weapons Removal and Abatement
PN	Proportional Navigation
POA	See UN-POA
Polisario Front	Frente Popular de Liberacion de Saguia el-Hamra y Rio de Oro (Popular Front for the Liberation of Saguia el-Hamra and Rio de Oro)
PR	Public Relations
PSSM	Physical Security and Stockpile Management
QW	Qian Wei (Advanced Guard)
RBS	Robotsystem
RMP	Reprogrammable Microprocessor
RPG	Rocket-Propelled Grenade
SACLOS	Semi-Automatic Command to Line-of-Sight
SADRAL	Systeme d'AutoDefense Rapprochee Anti-aerienne Legere (Light Short Range Anti-Aircraft Self-Defense System)
SAL	Semi-Active Laser
SALW	Small Arms and Light Weapons
SAM	Surface-to-Air Missile
SAS	Small Arms Survey
SFOR	Stabilisation Force in Bosnia and Herzegovina
SHORAD	Short-Range Air Defense
SIPRI	Stockholm International Peace Research Institute
SNA	Somalia National Alliance
SPADS	Self-Propelled Air Defense Systems
SPLA	Sudan People's Liberation Army
TAAG	Transportes Aereos Angolanos
UAV	Unmanned Aerial Vehicle
UEMS	Unplanned Explosions at Munitions Sites
UNIFIL	United Nations Interim Force in Lebanon
UNITA	Uniao Nacional para a Independencia Total de Angola (National Union for the Total Independence of Angola)
USAF	United States Air Force
UN-POA	United Nations - Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All its Aspects
USSR	Union of Soviet Socialist Republics
UV	Ultraviolet
VSHORAD	Very Short-Range Air Defense
VZM	Vazovski Machinostroitelni Zavodi
WA	Wassenaar Arrangement
ZIPRA	Zimbabwe People's Revolutionary Army
ZVBw	Zentrum für Verifikationsaufgaben der Bundeswehr (Verification Center of the German Armed Forces)

Throughout this *brief* acronyms are introduced the first time they are used. In addition, less common acronyms are reintroduced the first time they occur in each chapter.

Executive summary

The object of this BICC *brief* is to summarize the issue of Man-Portable Air Defense Systems (MANPADS) for political decision-makers concentrating on the potential effects of MANPADS on civilian aviation.

The *brief* is divided into chapters which cover the entire spectrum of issues relating to MANPADS effects in the civilian realm. Three main themes run through this *brief:*

Identification of the factors (technical, political, legal, security) that support or hinder MANPADS attacks against civilian aircraft.
The *brief* describes the history of MANPADS attacks against civilian aircraft and analyzes these cases. Control of MANPADS stockpiles and transfers are a key to restricting MANPADS attacks. Other critical features of MANPADS controls are the legal and diplomatic agreements, such as the Wassenaar Arrangement, which act to restrict MANPADS diffusion to some degree. Finally, we also discuss the concept of 'layered countermeasures' as a key to protecting civilian aircraft.

The effects of MANPADS attacks.
There is a continuing debate over the effects of MANPADS attacks against civilian aircraft. The *brief* identifies about fifty attacks. Some of these have been unsuccessful, others succeeded in bringing down an aircraft. Though some technical patterns emerge as to weapons used and aircraft survivability, the issue is complicated. Overall, propeller-driven aircraft are very vulnerable to MANPADS attacks, as are aircraft in the take-off phase. Immediate costs of an aircraft shoot-down are measured in the millions to hundreds of millions of euro. The longer-term effects are less clear cut, with some analysts claiming that a successful shoot-down would cost billions of euros in business disruption, insurance claims, and passenger confidence. Other evidence does not point to such dramatic effects. However, it seems likely that a shoot-down in Europe or the United States will have dramatic effects, whereas one in a less developed country will have far less impact.

Available tools to limit or halt MANPADS attacks.
There are a number of ways to affect the potential of attacks against civilians. While technical solutions (e.g. on-board countermeasures) seem, intuitively, to be an effective solution, these all have problems or weaknesses including cost, effectiveness or risks of collateral damage. Layered countermeasures, involving technical, legal and intelligence measures would seem to be more effective. However, there are two major tools available that have not been sufficiently exploited: security measures for MANPADS stocks—including inspections, 'smart gun' technology, good record-keeping, and storage technology—, and legal measures.

Security measures embedded in such proposals as the Wassenaar Arrangement's document on MANPADS provide a valid, useful security standard which needs to be enforced by all manufacturing countries on their clients. The embedded principles for transfer and storage, if followed religiously by both originators and recipients, are likely to significantly cut the access of undesirable elements to MANPADS.

Legal measures to ensure MANPADS security are unfortunately weak. Only one country, the United States, specifically legislates against the trade or ownership of MANPADS by civilians. Other states subsume legislation on MANPADS—a uniquely threatening weapon—into general legislation on war materiel. While over fifty countries have signed up to the detailed principles embedded in the Wassenaar Arrangement, many others have not. This is true for both, individual states and regional agreements. More work needs to be done to bring the remaining non-signatory states into line with the Wassenaar standards.

Finally, while detailed standards for transfer and stockpiling of MANPADS exist, there is some evidence that these standards are not adhered to even by states that are signatories to these arrangements. Moreover, a general weakness of all agreements to deal with MANPADS (bilateral as well as regional and international) is the lack of enforcement. Since participation is voluntary, there is no way besides name-and-shame (which signatory states seem loath to do) to ensure compliance.

Main findings

1. MANPADS and their components are very durable and can be functional after decades of storage even though inevitable degradation leads to an increasing loss of reliability.
2. Modern jet aircraft can survive being hit by MANPADS.
3. Attacks have almost exclusively taken place in active war zones. The threat to civil aviation outside conflict zones may thus be less grave than assumed.
4. The most commonly used MANPADS in attacks against civilian aircraft have been from the Strela

family, which are the most widely proliferated systems in the world. It can be expected that newer 2nd or 3rd generation MANPADS will become available to non-state armed groups in the coming years.
5. In the course of political chaos during regime change, MANPADS stockpiles are extremely vulnerable to leakage. In such situations, physical stockpile security measures could be a crucial factor in limiting MANPADS proliferation.
6. The quality and detail of international regulation of MANPADS has improved in the last decade, though enforcement is still weak. The strongest basis for MANPADS control is currently the Wassenaar Arrangement's MANPADS document.

Major recommendations

1. Encourage states manufacturing MANPADS to incorporate technical innovations to control illegal spread such as planned degradation of batteries and coded 'smart gun' mechanisms in all components.
2. Increase the development of passive counter-measures on aircraft and air crew training to protect against MANPADS attacks. Provide assistance to less affluent countries to secure the approaches to their airports and their aircraft.
3. Encourage manufacturers and militaries to move to less mobile CREWPADS rather than MANPADS, so as to limit attractiveness and discourage theft.
4. Encourage states to enact MANPADS-specific legislation.
5. Exchange real information about legacy MANPADS from manufacturers and stockpilers.
6. Encourage strong physical stockpile security measures to limit leakage in times of weak governmental oversight.
7. Develop a compliance mechanism for Wassenaar standards in the realm of MANPADS.

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Notwithstanding the above, the opinions expressed and the errors committed are our sole responsibility.

Introduction

Close upon their first deployment in the late 1960s as Very Short-Range Air Defense (VSHORAD), Man-Portable Air Defense Systems (MANPADS) became attractive weapons for Non-State Armed Groups (NSAGs) to defend themselves against aircraft in asymmetric conflicts, and as a terror weapon against civilian aircraft. The first recorded attempted attack against a civilian aircraft was in 1973 against an aircraft bearing Israel's then Prime Minister, Golda Meir. The attack at Rome's airport was foiled by Italian police before launch. Since then there have been some fifty recorded attacks by MANPADS against civilian aircraft by NSAGs and state military units, in addition to the hundreds of attacks, some successful, many not, against military targets.

MANPADS were developed as a military weapon by the United States starting in the late 1950s as an aerial defense for infantry units, and soon copied by the USSR. MANPADS are generally used militarily to:

- Protect light units (infantry and special forces) against close attacks by enemy aircraft (VSHORAD);
- Serve as an element in layered defense, notably in zones not covered by heavier mobile or static anti-aircraft defenses;
- Serve as a 'last ditch' defense for high value targets (e.g. HQs and VIPs);
- Ambush attacking aircraft from well-camouflaged unexpected positions, made possible by MANPADS easy mobility and small size.

MANPADS have been used in a number of state–state conflicts (e.g. the Cenepa War, the Yom Kippur War). They have been reported to be successful, though have not proven to be a major threat in such wars when utilized on their own, except in the ambush posture (that is, when they are used unexpectedly) or where the attacking aircraft or airforce have limited technical capacities. Nevertheless MANPADS are found in the arsenals of around 100 states. Early MANPADS were relatively ineffective against military targets. The newest versions have been improved in all aspects, and may constitute serious threats to military aircraft.

The prime goal of this BICC *brief* is to provide a comprehensive survey of all aspects of MANPADS as a problem in managing civilian security. The intention is to summarize the issue of MANPADS for political decision-making, concentrating on effects in the civilian realm. The issue is particularly crucial, since estimates of the direct and indirect damages that could occur from a single successful MANPADS attack are in the billions of euro. Moreover, since civilian air traffic is a major linchpin of modern business (freight as well as passengers), lack of confidence in this traffic system as result of a MANPADS strike would have severe worldwide economic impact.

The objectives of this *brief* are to:

- Enumerate and describe known attacks on civilian aircraft and what can be learned from those attacks;
- Describe the various types of MANPADS currently available;
- Describe what is known about the world MANPADS stockpile and MANPADS transactions between states and between states and NSAGs;
- Describe and analyze international and national attempts to regulate MANPADS and to provide technical and other civilian countermeasures to MANPADS attacks;
- Make recommendations to limit the threat of MANPADS to civilian aviation.

While we do discuss military data and related issues to some extent, it must be noted that the focus of this *brief* is on civilian MANPADS issues, not the military aspects of their use or deployment.

Structure

The *brief* is divided into seven chapters and a number of case studies, each of which, except the discussion and conclusions, is more-or-less autonomous.

In Chapter 1 we present and analyze attacks on civilian airliners from the 1970s to the latest attacks. We examine some of the effects and the nature of attacks including weapons (when known), aircraft types, attack profiles, and results.

Chapter 2 introduces the technical aspect of MANPADS insofar as these have been published. We describe both obsolete MANPADS and more advanced ones and analyze the role of their different components regarding attacks against civilian aircraft.

In Chapter 3 we document transfers of MANPADS from manufacturers to customers, and between states and NSAGs. The chapter also details what is known of the programs to destroy surplus MANPADS and draws some conclusions about this particular exercise.

Chapter 4 provides a picture of the world's stock of MANPADS as of 2011/12. Due to inconsistent data, it was necessary to devise and describe some methods that can be used to partially supplement published reports on MANPADS stockpiles.

In Chapter 5 we report on, and analyze, international, regional, and national attempts to regulate MANPADS through laws, treaties, and arrangements. We also assess the successes (and failures) of these regulatory attempts and point to some ways of improvement.

Chapter 6 describes and compares various technical and behavioral means to counteract MANPADS. We discuss means to disrupt MANPADS shoots, as well as means that have been developed to weaken the effects of hits should they occur.

In Chapter 7 we discuss and examine some of the major conclusions emerging from this study and provide some policy recommendations at both the national and international levels.

This *brief* is as comprehensive as we could make it within the scope of our research. Inevitably, there is too much information for some, and possibly too little for other readers. Therefore, we urge readers to read in depth those aspects of particular interest. The technology chapter is intended to provide readers with no or superficial knowledge of how MANPADS work with an authoritative source to the various types. Chapters 3 and 4 are of particular interest to readers interested in the state and effects of the MANPADS trade and stockpile control, whereas Chapter 5 presents a comprehensive view of the **normative and legal aspects of MANPADS control.** Chapter 6 is intended largely for readers who need coherent information on the current and future state of the techniques and processes for reducing the dangers of MANPADS hits. In a sense it is a continuation of the regulatory framework described in Chapter 5, including technical possibilities.

Method

Unsurprisingly for a military weapons system, data on many aspects of MANPADS are secret and not available for publication. Moreover, many aspects of the MANPADS issue even in the civilian domain are under-reported, vague, contradictory, or inaccurate. Most of the information in this *brief* has been reliant on publicly available documents including research papers, technical papers, manuals, newspaper reports and available correspondence. We have tried wherever possible to cross-check information from more than one independent source. Nevertheless, the data on some topics, including national stockpiles, international transfers, and users of MANPADS is inconsistent and not uniformly reliable, and must be seen as tentative and open to correction.

In addition to the publicly available documents, we rely on other supplementary sources. All known MANPADS producers were mailed a formal interview request. In addition, over 200 letters were sent to the official national contact points of the UN Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All Its Aspects (UN-POA). Only one MANPADS producer responded to our correspondence, denying the requested interview. However, eighteen national authorities provided us with information about their MANPADS regulations. In addition, several colleagues in various positions provided us with critiques and advice on puzzling aspects of the issue. We also benefited from a day's briefing and training at a *Bundeswehr* (German Armed Forces) facility, under the sponsorship of the Verification Center of the German Army (ZVBw). We have been greatly reliant on publicly available graphic sources, including photographs of MANPADS available on the web, and video clips available from various websites. Some of those have been authenticated by others; all have been examined by us carefully for a conservative interpretation of MANPADS presence in e.g. Syria and Libya, and for their use.

Data collection was communal, with the first draft of chapters written by different individuals on the team. Texts were then critiqued, first inside the team, with each chapter being overseen by at least two members, and the final product reviewed in-house at the Bonn International Center for Conversion (BICC), before review by external reviewers. Final editing and quality control were performed by BICC's in–house Managing Editor.

Princess Mawuena Amuzu

1

MANPADS attacks on civilian aircraft

Introduction

Commercial aviation is a major socio-economic world feature and therefore also a continuing target for terrorists. Attacks on civilian planes using Man-Portable Air Defense Systems (MANPADS), originally designed for military warfare to defend against aerial attacks, can occur, have occurred and arguably remain a threat (Brooks et al., 2005, p. 6; O'Sullivan, 2005, p. 2).

The use of MANPADS against civilian planes is almost as old as its use in warfare. Since 1973, there have been approximately 50 MANPADS attacks on civilian aircraft (in addition to other forms of attack such as hijacking and bombing). Although being illegitimate objects of war, hostile action against civilian targets has served as a terror tactic for a number of NSAGs (Non-State Armed Groups). The threat posed by MANPADS to civilian aircraft deserves much attention as one missile could cause a crash, killing scores of civilians. Though extensive damage to larger planes may be reduced due to their size, design, and multiple engine system, there is evidence of approximately 30 fatal attacks, and 920 civilian deaths (see Table 1 below). Of the MANPADS manufactured since the 1960s, over 6,000 are, it is claimed by some authors, outside official national armories or stored with questionable security (Pena, 2005, p. 4; Schroeder, 2007a). These estimates, however, pre-date the recent uprisings in the Middle East and the loss of control of state armories to non-state actors during which several thousand MANPADS may have been added to this count from Libyan stocks (Chivers, 2011a; Marrouch, 2012).

Air travel vulnerability has been a major topic of discussion since September 2001 with an evolving scope of actors, power shifts, heightened incidence of terrorism, and more inclusive security governance. The Mombasa Arkia Airline attack of 2002 and the DHL attack in 2003 (discussed below) brought to light the potency of MANPADS threats, sparking reflections and debates on the possibility of threats, vulnerability of the commercial airline industry and possible countermeasures (Isensen and Lindsey, 2002; Czarnecki, Yelverton and Brooks, 2005, p. 10). More recently, this issue has resurfaced as one of great concern with the developments in the Middle East, particularly the acknowledged threat of Libyan missiles and terrorist acquisition of these systems (Stewart, 2012). In addition to actual attacks, the threat of MANPADS attacks against civilian aircraft is a terror weapon of its own (Arasli, 2010). Though there is no evidence of a sustained and consistent rumor planting campaign of this sort, this should be kept in mind, since attacks against civilian aircraft are intended for public effect.

The objectives of this chapter are to summarize, with as much detail as possible, forty years of MANPADS attacks against civilian aircraft. With data gathered from open sources, this chapter of the *brief* proceeds with a short introduction to the vulnerability of large civilian aircraft, followed by a discussion of select past incidents, trends and impacts, and a conclusion.

It must however be recognized that neither the arguments nor the data are straightforward. Claims that an aircraft had been hit by a MANPADS can be hard to verify where technical infrastructure and aircraft crash reviews are not available. Thus even the numbers of successful attacks cited are open to challenge. The same is true of aircraft survivability in MANPADS attacks, and the overall effects of attacks on the international community.

MANPADS and the vulnerability of civilian aircraft

Civilian aircraft fly at relatively high altitudes and cruise levels that are out of reach of MANPADS. Their vulnerability to these weapons is, however, not eliminated. A wide window of opportunity is presented when a commercial jet descends into the 'danger zone' for landing or during take-off. This is due to its large size and lower altitude, as well as "predictable flight paths, slow speed, and high Infrared (IR) signatures" (Brooks et al., 2005, p. 6). Consequently, commercial flights are highly vulnerable within the time period of approximately 10 to 15 minutes before landing and after take off and for a distance of about 50 miles from the takeoff/ landing point (Erwin, 2003; Thompson, 2003).

History

The first recorded case of an attempted MANPADS attack against a civilian airplane was in Italy in 1973, orchestrated by the Black September Palestinian group.[1] The attack was foiled by the Italian security services before launch. Since then, civilian passenger and cargo planes have been periodically attacked. Reports regarding the total known number of attacks

[1] "Black September" was an internal PLO cell largely manned by Popular Front for the Liberation of Palestine (PFLP) personnel. Their main objective was attacks against the Jordanian government which had suppressed Palestinian armed groups in Jordan in September 1970.

range from 29 to 50 (Aviation Safety Network, 2012; O'Sullivan, 2005; Stratfor, 2010). This section first provides an overview of past attacks against civilian aircraft in Table 1 and an incident discussion of some selected cases.

Table 1: Recorded attacks

No.	Date	Aircraft	Engine	Fatalities	Attackers
1	15/01/1973	Israeli Government Flight Boeing 707	4 Jet Engines	0	Black September
2	05/09/1973	El Al Boeing 707	4 Jet Engines	0	Black September
3	14/03/1975	Air Vietnam	Unknown	26	North Vietnamese Forces
4	25/01/1976	El AL	Unknown	0	Baader Meinhof and PFLP
5	29/01/1978	French DC-4	2 Piston Engines	3	National Liberation Front of Chad
6	03/09/1978	Air Rhodesia Vickers 782D Viscount	4 Turboprop Engines	48	ZIPRA
7	12/02/1979	Air Rhodesia Vickers 782D Viscount	4 Turboprop Engines	59	ZIPRA
8	16/05/1981	TAAG-Angola Airlines	4 Turboprop Engines	4	Unknown
9	08/11/1983	TAAG-Angola Airlines Boeing 737-2M2	2 Jet Engines	130	UNITA
10	09/02/1984	TAAG-Angola Airlines Boeing 737-2M2	2 Jet Engines	0	UNITA
11	21/09/1984	Ariana Afghan Airlines McDonnell Douglas DC-10-30	3 Jet Engines	0	Afghan guerrillas
12	04/09/1985	Bakhtar Afghan Airlines Antonov AN-26	2 Turboprop Engines	52	Hizb i-Islami
13	16/08/1986	Sudan Airways Flight Fokker F-27 Friendship	2 Turboprop Engines	60	SPLA
14	05/10/1986	Corporate Air Services Fairchild C-123K Provider	2 Piston Engines	3	Sandinistas
15	05/05/1987	Sudanese Aeronau-tical Services Airways (SASCO)	Unknown	13	SPLA
16	11/06/1987	Bakhtar Alwatana Airlines Antonov AN-26	2 Turboprop Engines	53	Afghan guerrillas
17	09/11/1987	Air Malawi Shorts SC.7 Skyvan	2 Turboprop Engines	10	Mozambique Army
18	11/04/1988	Bakhtar Alwatana Airlines Antonov 26	2 Turboprop Engines	29	Afghan NSAG

Weapon used	Phase of flight	Point of impact	Outcome	Location of attack
Unknown	Landing	Unknown	Foiled in final minutes	Italy
Unknown	Unknown	Unknown	Foiled in final minutes	Italy
SA-7	En route	Unknown	Crashed	Vietnam
Unknown	Unknown	Unknown	Foiled in final minutes	Kenya
Unknown	Unknown	Unknown	Crashed	Chad
SA-7	Take off	Right wing	Crashed	Zimbabwe
SA-7	Unknown	Left engine	Crashed	Zimbabwe
Unknown	Unknown	Unknown	Crashed	Angola
Unknown	Initial climb	Unknown	Crashed	Angola
Unknown	Unknown	Unknown	Landed	Angola
Unknown	Unknown	Unknown	Landed	Afghanistan
Unknown	Take off	Unknown	Crashed	Afghanistan
SA-7	Take off	Unknown	Crashed	Sudan
Unknown	En Route	Unknown	Crashed	Nicaragua
Unknown	Unknown	Unknown	Crashed	Sudan
Unknown	Unknown	Unknown	Crashed	Afghanistan
Unknown	En route	Unknown	Crashed	Mozambique
Unknown	En route	Unknown	Crashed	Afghanistan

No.	Date	Aircraft	Engine	Fatalities	Attackers
19	08/12/1988	United StatesID flight 1 T&G Aviation – Douglas DC-7CF	4 Piston Engines	5	Polisario Front
20	08/12/1988	United StatesID flight 2 T&G Aviation – Douglas DC-7CF	4 Piston Engines	0	Polisario Front
21	28/06/1989	Somalia Airlines Fokker F-27 Friendship 600RF	2 Turboprop Engines	30	Unknown
22	21/12/1989	Doctors Without Borders IRMA/Britten-Norman BN-2A-9 Islander	2 Piston Engines	4	SPLA
23	12/6/1990	Aeroflot Uzbekistan Ilyushin 76MD	4 Jet Engines	0	Afghan guerrillas
24	22/02/1991	Antonov 26 Transport Flight	2 Turboprop Engines	47	UNITA
25	16/03/1991	Transafrik Airlines Lockheed L-100 Hercules	4 Turboprop Engines	9	UNITA
26	01/04/1991	ICRC flight	Unknown	0	UNITA
27	10/06/1991	Angolan Government Contract Cargo Flight	4 Turboprop Engines	7	UNITA
28	17/09/1991	ICRC Flight	Unknown	0	Unknown
29	28/01/1992	Azarbaijani Government Flight	Unknown	47	Armenian NSAG
30	27/03/1992	Armenian Airlines Yakovlev 40	3 Jet Engines	0	Unknown
31	03/09/1992	United National Flight Alenia G-222TCM Operators Aeronautical Militare Italiana	4 Turboprop Engines	4	Unknown
32	05/04/1993	United Nations Flight	Unknown	0	UNITA
33	26/04/1993	United Nations Flight Antonov 12B	4 Turboprop Engines	1	UNITA
34	25/06/1993	Aeroflot Airlines IAI Arava	2 Turboprop Engines	0	Abkhazian NSAG
35	22/07/1993	Tupolev TU-154 plane	Unknown	0	Abkhazian NSAG suspected
36	20/09/1993	Orbi Georgian Airways Tupolev 134A	2 Jet Engines	0	Abkhazian NSAG
37	21/09/1993	Transair Georgia Airlines Tupolev 134A	2 Jet Engines	27	Abkhazian NSAG
38	22/09/1993	Transair Georgia Airlines Tupolev 154B	3 Jet Engines	108	Abkhazian NSAG

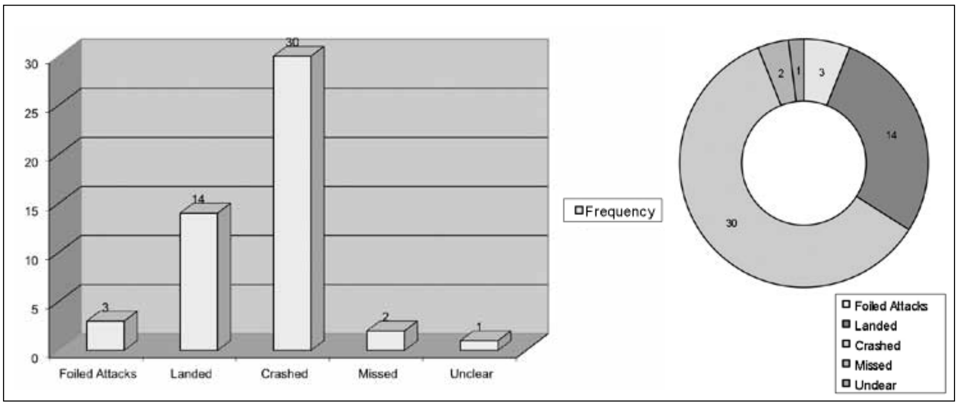
Weapon used	Phase of flight	Point of impact	Outcome	Location of attack
SA-7	En route 11,000ft	Engine	Crashed	Western Sahara
SA-7	En route 11,000ft	Unknown	Landed	Western Sahara
Unknown	Unknown	Unknown	Crashed	Somalia
Unknown	Take-off/ initial climb	Unknown	Crashed	Sudan
Unknown	Unknown	Engine	Landed	Afghanistan
Unknown	Unknown	Unknown	Crashed	Angola
Unknown	En route	Unknown	Crashed	Angola
			Landed	Angola
Unknown	Initial climb	Unknown	Crashed	Angola
	Unknown		Landed	Somalia
Unknown	Unknown	Unknown	Crashed	Azerbaijan
Unknown	Initial climb	Unknown	Landed	Armenia
Unknown	En route	Unknown	Crashed	Bosnia
Unknown	Unknown	Unknown	Landed	Angola
Unknown	En route	Unknown	Crashed	Angola
Unknown	Unknown	Unknown	Landed	Georgia
Unknown	Unknown	Unknown	Landed	Georgia
Unknown	Take off	Unknown	Unclear	Georgia
Unknown	Approach	Unknown	Crashed	Georgia
Unknown	Approach	Unknown	Crashed	Georgia

No.	Date	Aircraft	Engine	Fatalities	Attackers
39	06/04/1994	Rwandan Government - Falcon 50	3 Jet Engines	12	Rwandan Patriotic Front
40	29/09/1998	Lionair Flight Antonov 24RV	2 Turboprop Engines	55	Liberation Tigers of Tamil Eelam (LTTE)
41	10/10/1998	Congo Airlines Boeing 727-30	3 Jet Engines	41	Tutsi NSAG
42	26/12/1998	United Nations Flight Hercules Lockheed L-100-30	4 Turboprop Engines	14	UNITA
43	02/01/1999	United Nations Flight Hercules Lockheed L-100-30	4 Turboprop Engines	8	UNITA
44	08/06/2001	United Nations Flight	Unknown	0	UNITA
45	16/06/2001	United Nations Flight	Unknown	0	UNITA
46	16/06/2001	United Nations Flight	Unknown	0	UNITA
47	28/11/2002	Arkia Israeli Airlines Boeing 757-3E7	2 Jet Engines	0	Al-Qaida
48	22/11/2003	DHL Cargo Flight Airbus A300B4-203F	2 Jet Engines	0	Iraqi NSAG
49	23/03/2007	TransAVIAexport Cargo Plane Ilyushin 76TD	4 Jet Engines	11	al Shabaab
50	13/08/2007	Nordic Airways	Unknown	0	Iraqi NSAG

Sources: Aviation Safety Network, 2012; Berman, Schroeder, and Leff, 2011; Stewart, 2012; Stratfor, 2010.

The general outcome based on the above information is presented in Figure 1 below, where 30 of the 50 attacks resulted in crashes and 14 aircraft landed.

Figure 1: Outcome of past MANPADS attacks



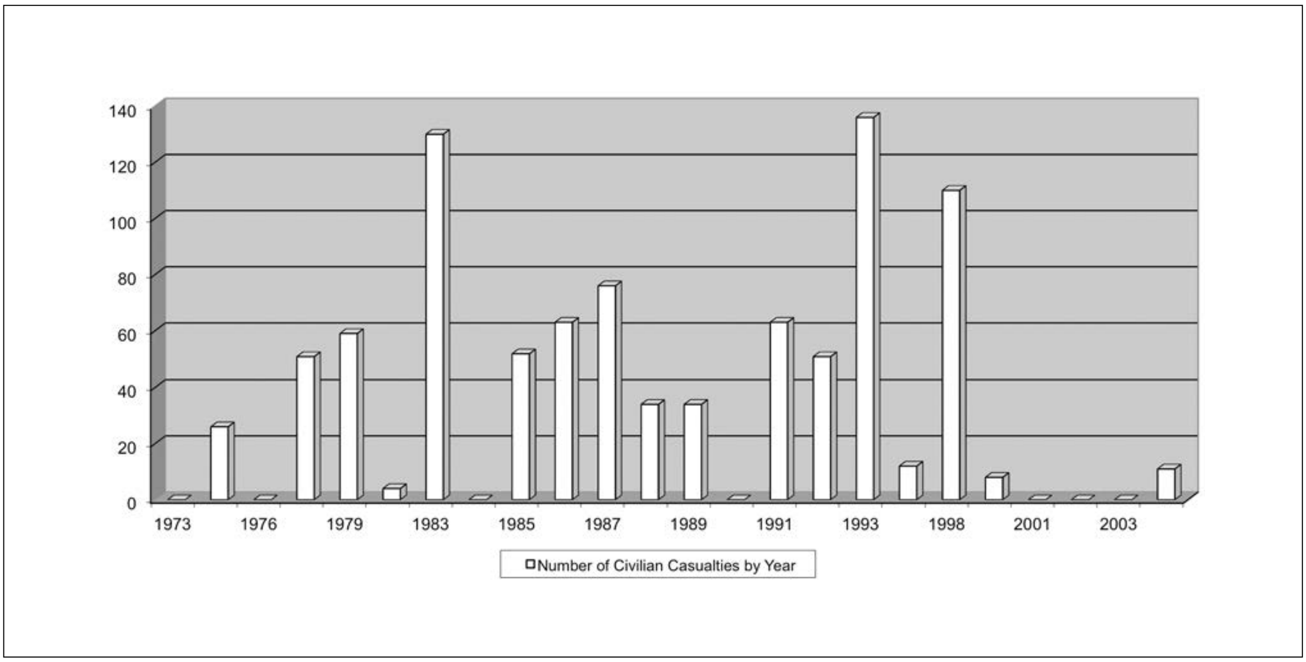
Source: Illustration based on Table 1

Table 1 illustrates that of the 50 incidents recorded through the years, seven occurred within 1970 and 1979 representing 14 percent. The most incidents occurred during the period 1990 and 1999, a total of 21 representing 43 percent. Although there appears to be a decline through the decade after that, this does not necessarily imply a reduction in the MANPADS threat. Figure 2 below illustrates the attacks by year. Since the 2007 Nordic Airways attack in Iraq, no other attack on a civilian aircraft has been recorded. It is conceivable that the peaks in attacks correlate with political events: major intra-state conflict, the dissolution of the USSR which made access to MANAPDS easier, and the Iraq War and its aftermath.

Since 1975, when the first civilian casualties from a MANPADS attack on a commercial aircraft were recorded, 920 deaths are attributed to MANPADS-related plane crashes (see Figure 2).

Weapon used	Phase of flight	Point of impact	Outcome	Location of attack
SA-16	Approach	Unknown	Crashed	Rwanda
Unknown	En route	Unknown	Crashed	Sri Lanka
SA-7	Take off	Unknown	Crashed	Democratic Republic of the Congo
Unknown	En route	Unknown	Crashed	Angola
Unknown	En route	Unknown	Crashed	Angola
Unknown	Unknown	Unknown	Landed	Angola
Unknown	Unknown	Unknown	Landed	Angola
Unknown	Unknown	Unknown	Landed	Angola
SA-7	Take off	Unknown	Missiles missed target	Kenya
SA-7	Take off	Wing	Landed	Iraq
SA-18	Take off	Wing	Crashed	Somalia
Unknown	Unknown	Unknown	Missile missed target	Iraq

Figure 2: Number of civilian casualties by year



Source: Illustration based on Table 1.

Box 1: Selected MANPADS attacks

Many MANPADS attacks against civilian aircraft have not been well-documented. A sample of the better documented representative events are noted here.

Zimbabwe 1978/79
On 3 September 1978, passengers on Flight 825, a Rhodesian Viscount aircraft from Salisbury en route to Kariba fell victim to a MANPADS attack. Known locally as the Hunyani Disaster, only eight of the 52 passengers and four crew members survived (ten of the casualties were reportedly as a result of ground fire after the crash). The SA-7 missile used in the attack was launched by the armed group the Zimbabwe People's Revolutionary Army (ZIPRA). The reported distress call before the crash indicated engine failure later confirmed as caused by the entry and 'explosion' of 'a heat-seeking missile hitting the inner starboard engine' (Herald Reporters, 1978). Apparently, the plane hit a gully during the attempt to land and broke up on impact (Herald Reporters, 1978).

Angola 1983
On 8 November 1983 at approximately 1520 hrs, a Boeing 737-2M2 was allegedly hit by a MANPADS. Operated by Transportes Aereos Angolanos (TAAG) Angola Airlines, the flight was en route to Luanda-4 de Fevereiro Airport from Lubango Airport. After a successful take-off and gaining an altitude of 200ft, the plane was struck and plunged, hitting the ground 800 m from the runway (Aviation Safety Network, 2012a). The National Union for the Total Independence of Angola (UNITA) rebels "claimed credit for downing the plane with a missile" (Berman, Schroeder and Leff, 2011) although there is no confirming evidence. The Angolan government however attributed this incident to technical malfunction. 130 people lost their lives.

Sudan 1986
On 16 August 1986, a domestic scheduled passenger aircraft was hit by an SA-7 weapon en route to Khartoum-Civil Airport from Malakal, South Sudan (Aviation Safety Network, 2012a). Of its 57 passengers and three crew members, no-one survived as the Fokker F-27 Friendship twin-propeller aircraft crashed after being struck shortly after take-off. This attack was attributed to the Sudan People's Liberation Army (SPLA) (Stratfor, 2010).

Rwanda 1994
A Dassault Falcon 50 executive jet, operated by the Rwandan government, was attacked by a MANPADS on approach to Kigali Airport. Aboard were the Rwandan President Habyarimana, and Burundian President Cyprien Ntaryamira returning from peace talks in Dar es Salaam, Tanzania (Berman, Schroeder and Leff, 2011). The attack occurred at approximately 2020 hrs on 6 April 1994 and resulted in the loss of all 12 passengers and crew. The missile was reportedly launched from Kanombe Camp, near the international airport, as the plane descended towards the runway. The plane burst into flames and crashed about 2 km (1.3 mls) east of Kigali Airport. The attack was probably launched by the Anti-Aircraft Battalion of the Armed Forces (Mutsinzi et al., 2009).

Kenya 2002
On 28 November 2002, an Arkia flight, Boeing 757-3E7 from Mombasa was target of a terrorist attack allegedly planned and carried out by Al-Qaida (Berman, Schroeder and Leff, 2011; Isensen and Lindsey, 2002). Two missiles were launched at the aircraft en-route to Tel-Aviv with 271 aboard—both missed. They were reportedly fired from Changamwe, (approximately 1.25 miles from the airport) where two launchers were later found (Kuhn, 2003, p. 26). The aircraft, used previously to transport Prime Minister Ariel Sharon in April of the same year, remained on course and landed safely in Tel Aviv.

In analyzing the attack, Kuhn (2003, p. 28) suggests a number of possibilities:

- countermeasures aboard the aircraft which had previously been used to transport Prime Minister Sharon,
- engagement altitude, which was extremely low, and
- faulty missiles probably due to age and improper storage.

Kuhn concludes that the altitude at which the aircraft was engaged was probably the prime factor (2003, p. 28), possibly caused by poor operator training (Thompson, 2003).

Baghdad 2003
On 22 November 2003, A DHL Airbus A300B4-203F, en route to Bahrain International Airport, carrying US Army mail, was attacked by Iraqi insurgents. Shortly after take-off (approximately around 8000 ft), the cargo plane was struck by an SA-7, in the wing, penetrating and igniting a fuel tank. Its three-man crew, despite the loss of the hydraulics system, successfully returned and landed at Baghdad Airport, notwithstanding the missile hit 'burning away a large portion of the wing' (Aviation Safety Network, 2012).

Somalia 2007
A Belarusian Transaviaexport IL-76TD 4 engine jet airlifter cargo plane was attacked by the armed group al Shabaab on 23 March 2007 resulting in a crash and 11 casualties (Stratfor, 2010, p. 6). The plane took off from Mogadishu and was attacked using two SA-18 missiles transfered from Russia to Eritrea which then transfered the missiles to the Somali NSAG (Berman, Schroeder and Leff, 2011; Stewart, 2012; Schroeder and Buongiorno, 2010a, p. 13).

Discussion

Weapon and perpetrators

It appears from the above tables and cases that the most common type of MANPADS used in attacks are the Russian Strela (SA-7) models, although others have been used as well. These are relatively cheap on the black market with single units costing as low as US $5000 (Schroeder and Buongiorno, 2010b). In 1994, the Rwandan attack involved SA-16 systems (Stewart, 2012). More recently, in the 2007 Somali attack, 2 SA-18 MANPADS were used (Berman, Schroeder and Leff, 2011), routed through Eritrea (Stewart, 2012).

Data concerning the human element in firing a MANPADS is somewhat contradictory. On the one hand, MANPADS are designed for ease of use, with newer MANPADS built with aiming aids to ensure accuracy (see Chapter 2). Our own brief hands-on experience with MANPADS showed that the basic actions are relatively straightforward. Whether we, as untrained operators, would be able to fire **and hit** successfully, is moot. On the other hand, there are claims that poor operator training has a major effect. Thus Thompson (2003) contends, for example, that the attack on an Arkia aircraft in 2002 failed due to poor operator training though Kuhn (2003) argues other factors might have been more important. In Afghanistan, where the anti-Soviet Mujahidin received several types of MANPADS from the CIA, poor training is claimed to have led to many misses (Urban, 1984). Video clips from the Syrian civil war (see for example Table 8, items 5, 10) seem to indicate that while basic practice using a MANPADS is simple, actual firing under battlefield conditions is not.

More advanced MANPADS require less training as many functions are automated to a lesser or greater degree and the warheads are more lethal. Thus should an NSAG acquire a more advanced MANPADS, it is also likely to be more lethal (see Chapter 2). Overall, we would argue that it is difficult to operate a MANPADS successfully **under battlefield conditions** when the operator is under threat. Using MANPADS under less threatening conditions may require less training. More modern MANPADS are easier to operate than those from older generations.

NSAGs and MANPADS

It appears from the previous section that most of the perpetrators of attacks against civilian aircraft have been ideologically driven NSAGs whose acts, recruitment and training are commonly outside the control or influence of state actors. These NSAGs, do not operate within the frame of international law. Their covert operations, training and weapon acquisition are reliant on the gray and black markets (see Table 31 in Chapter 4 for a tentative list of NSAGs with MANPADS). NSAGs with the motivation to use MANPADS against civilian aircraft are spread throughout the world, thereby increasing the existing threat arena with regard to civilian attacks. Currently, some 47 NSAGS are believed to have held, or be holding, MANPADS of various models (Small Arms Survey, 2012). A large 'pool' of available MANPADS such as those in Libya, and, potentially, Syria, would exacerbate the situation and bring MANPADS into many more hands (cf. Stewart, 2012). MANPADS transfers from manufacturing states such as the United States and Russia to NSAGs seem to have declined, though there is evidence that secondary manufacturing states such as Iran were still providing MANPADS through the gray market until fairly recently (Gertz, 2007; Schroeder, 2008; US Department of State, 2008). Given the fluidity and interconnections of NSAGs, it is highly likely that MANPADS will spread from the 47 on the Small Arms Survey list to other organizations.

Aircraft vulnerability and outcome

MANPADS have been used to attack different civilian aircraft models, sizes and capacities over the years including an Airbus A300, a Fokker F-27 Friendship, an Ilyushin 76, an Antonov 26, a Dassault Falcon 50, a Vickers Viscount and a Boeing 737. What then, can the vulnerability, survivability and impact sketch reveal, considering the wide range of aircraft and engine types? The vulnerability and extent of damage to civilian aircraft attacked by MANPADS is contested by flight specialists and aeronautical engineers. Stewart (2012), argues that as MANPADS warheads were originally designed to destroy "military aircraft densely packed with fuel and ordnance", their size, capabilities and suitability for larger aircraft 'kills' are doubtful. Larger aircraft generally have multiple "… high-bypass engines [which] produce less heat" and "… can fly on one engine" (Thompson, 2003), making it likely that aircraft with multiple engines can survive the attack. Schmieder (an aircraft research engineer) claims, too, that these "… missiles are too small to take out a passenger jet [as] … commercial jets are designed to cope with losing an engine and can fly on just one" (cited in Duffy, 2003). Adding to the debate, Kuhn (2003, p. 29) states that "the engine body and cowling of an airliner may mitigate most of the blast from a missile entering the engine." He notes, however, that this will cause immediate engine 'shut down' and in the event of twin-engine loss for large aircraft (as was intended in the 2002 Mombasa attack), survival chances are poor. These arguments aside, the fact is that commercial aircraft *have* been attacked successfully and fatally. As successful attacks such as the Ilyushin attacked in Mogadishu show, large commercial aircraft *can* be hit and may consequently crash.

Analysis of a highly technical issue from a socio-political perspective is always fraught. Nevertheless, four critical variables emerge from examining the data about successful and unsuccessful attacks (see Table 2): engine numbers, engine types, hit location, and pilot skill.

Though multi-engine aircraft have been attacked successfully (e.g. Somalia 2007 [a four engine Ilyushin 76], and the Air Rhodesia attacks 1978 and 1979 [both four engine Viscounts]), some have survived attacks (Arkia 2002) and even hits (DHL Boeing 737). This seems to indicate that multiple engines alone do not offer a defense against MANPADS attacks.

A more significant variable appears to be the engine type concerned. Overall (see Table 2), aircraft with piston or turboprop engines (whether multiple engines or not) are much more vulnerable to MANPADS, suffering both hits and crashes to a greater extent than jet-propelled aircraft. This may be because propeller aircraft are inherently slower, or because they fly at lower altitudes (both a function of the type of propulsion), or possibly because they are older and thus lack many of the safety redundancies present in more modern jets.

The third critical variable appears to be hit location. Schaffer, while arguing that commercial aircraft are relatively safe from MANPADS, acknowledges that on the issue of survivability, "a crucial determining factor is where on the aircraft the missile or its explosive debris hits" (1998, p. 76). Indicating that an aircraft has a number of "points of vulnerability to explosive trauma", he notes that the severance of critical cables or "… explosive detonation in or near a fuel tank" will cause a 'massive explosion', fire or loss of control thereby causing a crash. In large aircraft, the "explosive loss of an engine or … a substantial gap in a wing or fuselage could cause large asymmetric yaw or pitch movements" (ibid.).

Since aircraft are reliant on hydraulics and fuel pipes extending to the wings, an explosive entry point in the wings may be fatal. This is consistent with the reported events of the DHL- Baghdad 2003 case which was hit in the wing by an SA-7, igniting a fuel pipe. Closer analysis of hit results conducted empirically by Czarnecki et al. (2011a, p. 6) who tested MANPADS hits on testbed commercial jet engines argue that there is the need to generate 'likely engagement outcomes' to better understand and mitigate the existing potential for an aircraft kill. This requires analysis through threat models testing, for instance, the sustainable blast damage, and also missile body debris penetration (Czarnecki et al., 2011b). The authors further indicate that the "most likely impact point for a MANPADS is on an aircraft's engine" (ibid.), somewhat contradicting Kuhn's observation that terminal guidance algorithms direct many missiles away from the engine towards the airframe. Besides this, however, the critical factors appear to be point and angle of entry, level of likely damage, and resultant effect on control and maneuverability.

This variable also touches upon the nature of more advanced MANPADS. As Kuhn (2003, p. 29) points out, modern MANPADS such as the newer FIM-92 Stinger and Igla families possess a capacity that redirects the missile's flight path towards the body of the aircraft, rather than the hot exhaust of the engine during the terminal phase of missile flight. This, in a civilian aircraft, will lead to "… possible loss of control surface" (Kuhn 2003, p. 29), destroyed wing flaps, thus making the craft unmaneuverable, further decreasing the chances of survival. Furthermore, early generation MANPADS with lead sulfide-based detectors, which are principally implicated in attacks against civilian aircraft, are only able to lock on to the extremely hot exhaust plume of jet engines. Reduced heat signatures would arguably lower the chances of being hit (see Chapter 2 for more information on seeker technology). Later generation MANPADS with indium antimonide-based detectors, in contrast, are able to lock on to the cooler airframe as well, making them more effective against targets with lower heat signatures. Moreover, improvements in warheads (see Chapter 2) such as shaped charges and continuous-rod warheads are likely to cause spalling which would create even greater damage to control surfaces and possibly to passengers in the body of the aircraft, leading to loss of life due to crashes or onboard fatalities.

Table 2: Aircraft engine type and outcome of attack

Type of engine	Number attacked	Outcome of attack
2 Piston engines	3	Landed - Crashed – 3 Foiled - Missed -
4 Piston engines	2	Landed – 1 Crashed – 1 Foiled - Missed -
2 Jet engines	6	Landed – 2 Crashed – 2 Unclear – 1 Missed -1
3 Jet engines	5	Landed – 2 Crashed – 3 Foiled - Missed -
4 Jet engines	2	Landed – 1 Crashed – 1 Foiled - Missed -
2 Turboprop engines	9	Landed - 1 Crashed – 8 Foiled - Missed -
4 Turboprop engines	9	Landed - Crashed – 9 Foiled - Missed -
Unknown	14	Landed – 6 Crashed – 3 Foiled – 3 Missed – 1

Source: Based on Table 1

The Baghdad incident illustrates a fourth variable: even in the event of damage to critical components, and in this instance the partial destruction of a wing, skilled conduct by a crew can nevertheless bring a plane down to land safely after a successful hit. However, Hughes points out that "…in landing the aircraft [the pilots] displayed superb airmanship. People have tried to replicate this incident on simulators, and, as yet, nobody has been able to land an aircraft [under similar conditions]" (2007, video, 10:17–10:29). This suggests that even with very good training a sizable portion of luck is required to be able to safely land the aircraft.

To conclude this discussion, putting together the various arguments and the available data, we can determine the following:

- Propeller-driven aircraft have proven to be highly vulnerable to all types of MANPADS. Jet aircraft are less vulnerable.
- Multiple engines increase aircraft survivability, though there is insufficient conclusive evidence whether the size and category of the plane determine 'survivability' (Thompson, 2003).
- The likelihood of critical systems failure depends on the location of the MANPADS hit as well as the type of warhead.
- Most attacks against civilian aircraft have been by relatively older MANPADS, which has resulted in many unsuccessful attacks.
- There is insufficient evidence to determine whether modern MANPADS such as later Stingers and Igla-S are more effective against civilian jet aircraft, though it would appear that the effects of improved and larger warheads and better targeting abilities may cause major damage and likely crashes.
- Pilot skill can, admittedly under extraordinary circumstances, mitigate the effects of a MANPADS hit even in critical systems.

Phase of flight

The aircraft on which data was acquired were at different stages of flight when attacked. However, available information is incomplete. After take-off, during initial climb, as well as through the gain in altitude, aircraft are very vulnerable to MANPADS, as indicated in Table 3. From available information, the most hits resulting in crashes were just after take-off, during initial climb, and en route before cruise altitude. Within the table, flights attacked during initial climb, are categorized as 'Take-off', and 'Landing' includes the entire approach as the aircraft starts descending from cruise altitude. The 'en-route' phase indicated here does not refer solely to cruise altitude but includes cases where the exact speed, velocity during attack are unknown. Cruise altitudes differs but are approximately 10,000 meters for jet aircraft (out of range of MANPADS which have an engagement altitude ceiling of approximately 1,500–7,000 meters. See Chapter 2). Prop-driven aircraft have a generally lower cruise altitude, putting them at more risk. Attacks in which reliable data regarding actual phases were unattainable are placed under 'Unknown'.

that attackers have less lead time to prepare during a landing phase. In summary, the data on aircraft and flight appear to indicate that, for inconclusive reasons, most attacks have been during the take-off phase of the flight. However, propeller-driven planes, which are much slower than jets and fly at lower altitudes, are vulnerable even during the cruise phase of their flights.

Attack location and civilian targets

Targets of MANPADS attacks, including survivors, have been heterogeneous. Besides government officials such as the attempted assassination of Prime Minister Golda Meir in 1973 and the successful assassination of Presidents Habyarimana and Ntaryamira in 1994, victims on attacked civilian flights have included crew, doctors (Doctors Without Borders, 1989), tourists (Air Rhodesia 1978/1979), development aid workers (US AID flight 1988), United Nations staff (UN Flight 1992; 1993; 1998; 1999; 2001), and undifferentiated civilians. The total number of civilian casualties of MANPADS stands at 920 (see also IFALPA, 2006; Stratfor, 2010).

Table 3: Phases of flight and outcome

Phase of flight	Number of attacks	Crashes	Missed targets	Planes landed	Attempt foiled	Unclear
Take-off	12	8	1	2	0	1
En-route	12	11	0	1	0	0
Landing	4	3	0	0	1	0
Unknown	22	8	1	11	2	0
Total	50	30	2	14	3	1

Source: Derived from Table 1.

Most attacks were directed at aircraft in take-off and en-route phases. In eleven cases, aircraft managed to land without any indication of the phase of flight (see Table 3).

Table 4 below summarizes the findings for those cases where type of aircraft and phase of flight data are available.

Most attacks occurred during take-off and en-route. However, a large number of the latter occurred against **turboprop** planes, which, given turboprop craft's relative slowness, and relatively lower flight path make them more vulnerable. Somewhat surprising is the low number of attacks during landing, when one would expect the aircraft to be more vulnerable to attack as it powers down on approach. It may be

With a few notable exceptions, most MANPADS attacks against civilian aircraft have taken place in active war zones. Due to the nature of warfare in the latter half of the 20th century which has been preponderantly intra-national in nature, these war zones may not have been 'officially declared' but were nevertheless areas of ongoing violent conflict. Most victims, perhaps as a consequence, were engaged in what might be called 'peri-military' activities: UN personnel, medical personnel and other professionals engaged, at some remove perhaps (e.g. development personnel), and as neutrals, in conflict zone activities.

Two exceptions stand out. The 2002 attack against an Israeli flight filled with tourists flying from Mombasa was outside a war zone, though a terrorist action within the framework of an ongoing violent conflict.

Table 4: Phase of flight and type of aircraft

	Number of attacks	Outcome	Phase of Flight: Take-off	En-route	Landing	Unknown	Total	Percentage by engine type
Piston-drive engine	5	Crashed	1	2		1	4	80
		Landed		1			1	20
		Missed						
		Foiled						
		Unknown						
Turboprop engine	18	Crashed	4	8		5	17	94
		Landed				1	1	6
		Missed						
		Foiled						
		Unknown						
Jet engine	15	Crashed	3		3		6	40
		Landed	2			3	5	33.3
		Missed	1				1	6.6
		Foiled			1	1	2	13.3
		Unknown	1				1	6.6
Unknown engine type	12	Crashed		1		2	3	25
		Landed				7	7	58.3
		Missed				1	1	8.3
		Foiled				1	1	8.3
		Unknown						

Source: Derived from Table 1.

The destruction of an aircraft carrying the presidents of Rwanda and Burundi by elements of the Rwandan military was an assassination during peacetime.

This has two implications. First, the ability and perhaps the willingness of terrorist groups to attack civilian aircraft outside war zones appear to be limited. For unclear reasons, NSAGS have not, effectively, conducted MANPADS attacks in non-war zones. Second, this implies that the overall threat of MANPADS attacks against civilian air traffic in areas such as North America and Europe may well be exaggerated. Terrorist organizations may not have the capacity, or may be inhibited by better security in developed countries. Certainly the will and ability to create civilian air traffic terrorist incidents involving other means has been well demonstrated.

The two exceptions demonstrate the rule. In the Rwandan case, internal sedition effectively bypassed what would have been normal security provisions. In the Israeli case, Israel's robust civilian air security, including control of areas that could threaten its international airport, and possibly technical countermeasures meant that the attackers had had to choose a site in a less-developed country where on-the-ground security was expected to be weak.

Effects of MANPADS attacks on civilian aviation

The commercial air transport industry contributes to the overall economic growth of nations, is crucial for international trade, and provides tax income. Its relative importance is evident in its global economic volume which currently stands at US $2.2 trillion and 56.6 million individuals employed in aviation and related tourism (IATA, 2012). An attack against such a major economic sector could be expected to produce significant effects.

When examining the effects of successful MANPADS attacks against civilian aircraft, a number of issues need to be disaggregated. Two notable analyses, one by the US military (Whitmire, 2006), the other by the Rand Corporation (Chow et al., 2005) differentiate between immediate and long-term costs. In addition, a number of other variables need to be considered. Crucially we believe, these are the location of the attack and the number and characteristics of the victims.

The immediate costs of a successful attack include, but are not limited to monetary losses. Loss of lives (in the aircraft and possibly on the ground), as well as trauma and subsequent fear of flying in the case of survivors are likely. In addition, there will be destruction and loss of property (including the plane and its cargo) and possibly on the ground. Direct costs of a successful attack were estimated by Chow et al. to be US $1 billion (2005, p. 7). To provide a standard, the Libyan government paid some US $2.16 billion to the families of the Lockerbie victims (on the ground and in the air). PanAm, the plane's owner claimed US $4.5 billion for the loss of the aircraft and the effect on the airline's business. An immediate cost of some US $1 to 4 billion in total would therefore seem to be a reasonable figure (keeping in mind that the Lockerbie figures emerged after lengthy wrangling, and that the airline undoubtedly inflated its demands).

In addition to the immediate costs, there are extended long-term effects. Required insurance premiums are likely to soar while productivity dips due to reduced patronage (cf. Australian Government, 2008, p. 17f). Immediately following an attack, there are 'corporate travel freezes and leisure trip cancellations' which cause a 'decline' in industry performance (Whitmire, 2006, p. 21) due to security concerns and loss of confidence in aviation. Indeed, tourism to Kenya did decline drastically after the unsuccessful 2002 Mombasa attack, though it recovered to normal levels within six months.

The September 11 terrorist attacks caused a 35 to 40 percent drop in airline revenues in the last quarter of the year in the United States (Pena, 2005, p. 2). Related job losses occurred in the aviation industry and interrelated sectors as well. Chow et al. argue that indirect but immediate costs such as shutdown of flights after an attack need be considered as well. They estimate the costs of a one week shutdown to be about US $3 to 4 billion in the United States alone (2005, p. 9). If reluctance to fly is factored in, the total cost of a one week system-wide shutdown might exceed US $15 billion (Chow et al., 2005, p. 9f).

Attempting to estimate losses from a putative MANPADS attack requires one to keep in mind a number of factors. First is the available data from MANPADS attacks. Second are possible analogies and their validity. Third is a careful parsing of relevant attack variables.

As we have noted above, there have been a number of **successful** MANPADS attacks against civilian aircraft in the past four decades. Two closely related issues need to be kept in mind about the successful attacks: they occurred in war zones or less-developed locations, and the effects of the attacks **on world aviation traffic** were minimal. We argue that these two features are related: as air traffic in the developed world was not affected, for most people in North America and Europe (unless personally affected) these shoot-downs were little more than a news item from a faraway location. Thus where the attack takes place, and, critically, who the passengers were, is an important variable. To put it bluntly and rather sadly: an attack involving largely non-Western aircraft, personnel and location would likely be less costly overall than one involving US or Western interests or actors generally, and have less media effect.

Both Whitmire (2006) and Chow et al. (2005) use the analogy of the 9/11 attacks in the United States as a baseline for their estimates. This analogy must be taken with great caution. The 9/11 events were not simply bombings as had happened before (for instance in Lockerbie 1988). They differ in both material and psychological dimensions from a single shoot down by a MANPADS. Materially, four planes were involved, as well as deliberate and massive damage on the ground. Psychologically, the event was drawn out, dramatically visible and audible, and concluded with massive effects ranging from the destruction of a major landmark to the nominal "War on Terror" and an actual war in Afghanistan with all the legal implications and changes in security practices for airlines passengers.

It seems doubtful to us that the shooting down of an aircraft by a MANPADS would have a similar effect **unless the context and effects were as dramatic as 9/11.** It should be noted that large civilian aircraft have been shot out of the sky (with loss of life) in the past (Aviation Safety Network, 2012), yet the long-term effects have not been as significant or economically costly as claimed by Chow et al. and Whitmire.

The psychological effects of a MANPADS attack are an element in the long-term effects. However, whether a MANPADS attack will have a substantially greater effect than any other kind of air terrorism remains unproven. Presumably, the reaction to a MANPADS attack will depend on a number of factors.

These would include:

- Where the attack took place (within North America and Europe would have much more long-term impact than elsewhere in the world);
- Whether the perpetrators were apprehended and air travel was declared safe within a short period of time;
- The nature of the attack (e.g. multiple successful attacks would leave a more lasting impact than a single attack);
- Government and industry responses, and the availability of substitutes for air travel;
- Local psycho-cultural factors, such as previous national experience with terrorism.

It seems unlikely that worldwide panic or worldwide economic downturn would result from a single MANPADS attack. The analogy of other passenger aircraft shot down (Aviation Safety Network, 2012a list a number of major aircraft losses to non-MANPADS ground attacks, the most recent in 2001) indicates no worldwide panic. The growing frequency of global travel for individuals, with world air traffic increasing every year, **could** mean a growing personal interest in passenger safety by potential passengers, and thus greater sensitivity to aircraft failures, including MANPADS-caused, but evidence is still lacking.

To summarize, our own feeling is that a single successful MANPADS attack would not be a unique event, and its effects would be similar to those of other forms of air terror. Multiple attacks, a major aircraft crash, and successful attacks in the developed world are unlikely to have greater effects simply because the terror instrument was a MANPADS.

Conclusion

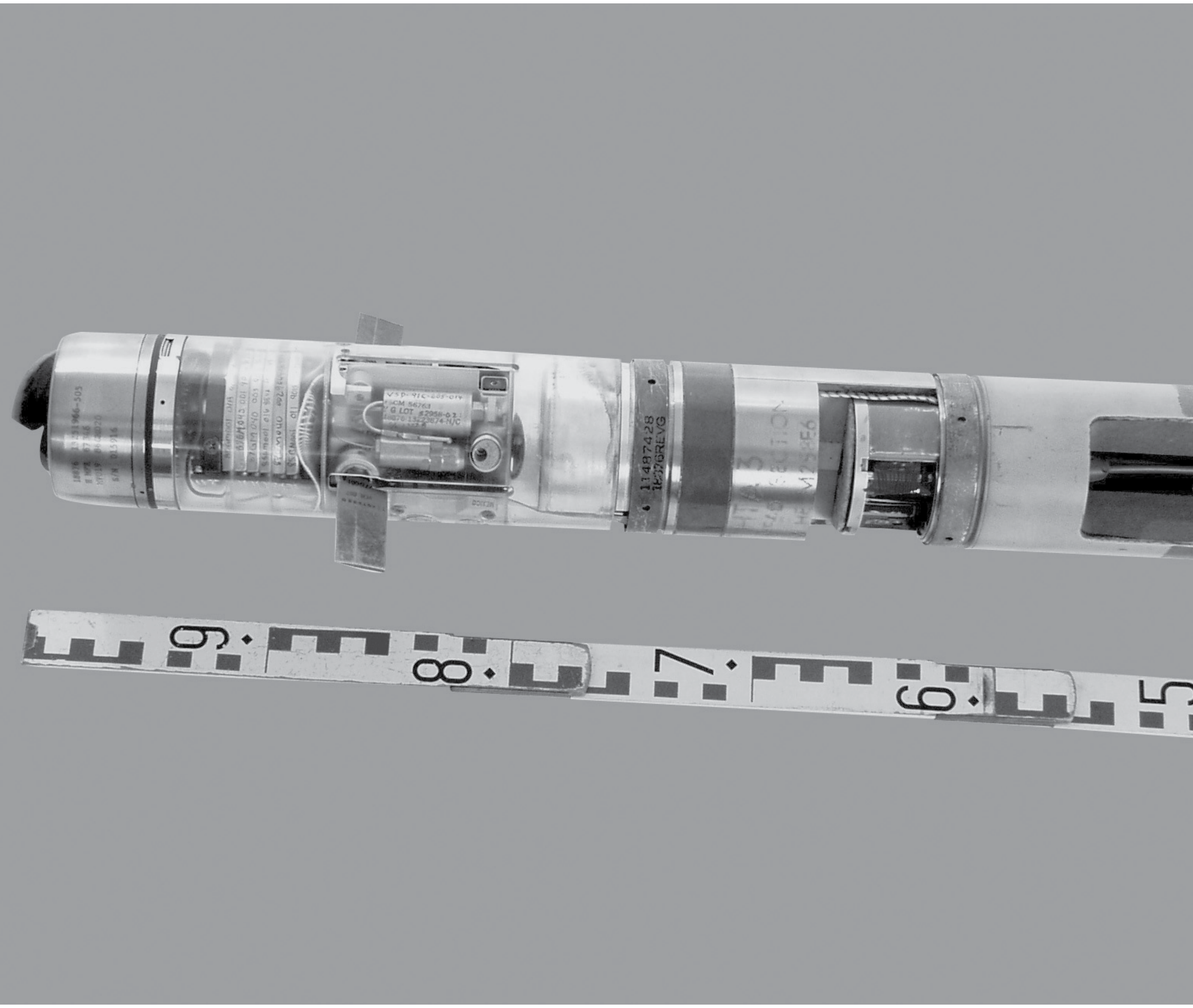
Civil aviation has been a prime target for some NSAGs and terrorist groups.[2] Attacking a civilian aircraft creates immediate disruption, but, more importantly, it gives credibility to the NSAG as an armed threat, has major repercussions and therefore offers major exposure to the group's ideals, and can serve as a motivational and recruitment tool. The threat of such attacks has been acknowledged almost universally (see Chapter 5), and drives policy, cooperation and technology. The major conclusions of this chapter are:

- Approximately 50 aircraft of various sizes, engine types and configurations have been attacked leading to an estimated loss of 920 civilian lives.
- Aircraft kills have resulted from impact-related fires, explosions and crash landings due to loss of control.
- Aircraft can survive a hit by MANPADS, even though the chances are low. The four significant factors appear to be type of aircraft (jets have survived better), point of impact (impact on exhausts improve survivability), type of missile used (older missiles are less effective), and pilot training and skill.
- Most attacks have occurred during take-off and in the en-route phase.
- Propeller-driven aircraft are inherently more vulnerable than jet aircraft and can be hit even at their cruising altitude.
- The most commonly used MANPADS in NSAG attacks have been Strela family, though others have been used as well. No later generation MANPADS (advanced Stingers or Igla-S) have been implicated in attacks.
- Most MANPADS attacks take place in war zones, with only two documented attacks outside them, and no attacks within the airspaces of developed countries.
- The short-term effects of an attack are fairly well understood. Long-term effects which may include effects on air travel are not unambiguously known, though so far there is no evidence that these effects will differ from other forms of attacks against civilian aircraft.

[2] Why some NSAGS have targeted civilian aircraft (bombs, hijacking, and MANPADS included) and others have not is a relevant question but beyond the scope of this *brief*.

Christof Kögler

2 Technical aspects and components of MANPADS



This chapter will examine the architecture of different types of MANPADS, as well as their components, as a basis for understanding the threat these weapons represent. It will first identify the components of MANPADS, describe the role they play in the MANPADS' functioning, and assess component criticality.

The second part of this chapter will analyze to what extent the characteristics of each individual component can contribute to limiting the proliferation of MANPADS. This can be the case (a) when a component is sensitive to shock, extreme temperature, improper storage or handling and thus has an increased chance of failure as time progresses, (b) when a component increases the complexity of the MANPADS and makes it significantly harder to operate without proper training, (c) when a component plays a particularly critical role in the MANPADS' functioning (d) when a component is difficult to replace with spare parts or with improvised craft components.

MANPADS architectures—An overview

Out of the wide array of possible strategies to guide a missile to its target, only three have been used in MANPADS: nearly all missiles rely on **passive homing** and **command guidance;** the exception is the Chinese FL-2000B (QW-3) which employs a **semi-active homing** system.

In **passive homing,** the missile is equipped with a sensor unit (the 'seeker') that tracks radiation 'naturally' emitted by the target. This approach has several consequences:

1. After launch, no further communication between operator and missile is necessary, which has earned this type of missile the nickname 'fire and forget'. As the gunner does not have to track the target after launch, he can reposition himself to evade incoming fire or acquire another target.
2. It does not rely on an external source of radiation to 'illuminate' the target, and thus does not alarm the target that it is being attacked.
3. The missile is susceptible to decoys that imitate the radiation emitted by the target.

Passive homing is the technique employed by the vast majority of MANPADS. It is used by the US Redeye and Stinger, the Japanese Type 91, South Korea's Chiron (also known as Singun), and the French Mistral. The most significant representatives of this missile type, however, are the Russian Strela and Igla families, as they are the most copied and most widely available MANPADS in the world. Amongst its various derivatives and reverse engineered models are the Egyptian Sakr Eye, the Chinese HN-5, QW-1 and QW-2 series, the Polish Grom-2, Romania's CA-94M, Pakistan's Anza family, as well as the Iranian Misagh series.

In **command guidance**, the unit which tracks the target is 'outsourced' to a system on the ground. It then communicates guidance commands to the missile and thus directs it to the target. This has several implications:

1. The missile is reduced to warhead, (flight) control unit, propulsion, and a receiver for guidance commands from the ground. That makes it more lightweight and reduces missile costs.
2. The gunner needs to track the target until impact (usually maintaining line of sight with the target) and is thus more exposed to attack.
3. Both missile and target have to remain within line of sight until impact, somewhat limiting the engagement envelope.
4. The launching unit needs to track the target, calculate a missile course, and transmit the relevant data to the missile. It is thus bulkier and heavier, making it less mobile. In most cases, this type of MANPADS is fired from a tripod rather than from the gunner's shoulder.
5. The missile is immune to most counter-measures (cf. Chapter 6).

Command guidance, usually in a beam-riding configuration, is employed by two MANPADS families. The first is the British Blowpipe, Javelin, Starburst, and Starstreak series. The Blowpipe was used in Afghanistan in the 1980s, as well as in the Falklands War, where it proved very ineffective. Out of 100 launches only two succeeded in downing the target (Hillson, 1989; Freedman, 2005, p. 734). The gunner needed to track both the missile and the target, and had to steer the missile to the target manually. In later members of the series, the missile is tracked automatically by the launching unit, which also assists the gunner in tracking the target. This approach is called semi-automatic command to line-of-sight (SACLOS) guidance. The second series of MANPADS to rely on command guidance is the RBS-70 family, produced by Saab-Bofors in Sweden. Both Starstreak and RBS-70 use a laser beam to guide the missile to its target. While they have performed well in tests, the newer command guided missiles are yet to be tested under battlefield conditions. Generally, command guided missiles are far less common and less widespread than the passive homing variants.

The ‘odd one out’, **semi-active homing,** while unusual for MANPADS, is frequently employed in precision-guided munitions, like laser-guided bombs or missiles. It is ‘semi-active’ in that the target is illuminated by an outside source, in the case of the QW-3 a ground-based laser. The missile is equipped with a seeker which detects the reflected laser light. This means that:

1. Like with passive homing missiles, no further direct communication between gunner and missile is necessary after launch.
2. The gunner (or another ground-based unit) needs to illuminate the target with a laser beam until intercept and is thus more exposed to attack.
3. Through the illumination, the target has a high chance of being alarmed of the attack.
4. The missile is immune to most counter-measures.

The only specimen of this type is the FL-2000B variant of the Chinese QW-3 MANPADS (the FL-2000 variant employs infrared passive homing), which entered service with the Chinese armed forces in 2005 (Richardson, 2003; NA, 2007; Jane’s, 2012a; NA, 2009). It should be noted that it remains unclear whether this system is available in a MANPADS configuration at all or only as a self-propelled system. For the sake of comprehensiveness, the technology will be included here nonetheless.

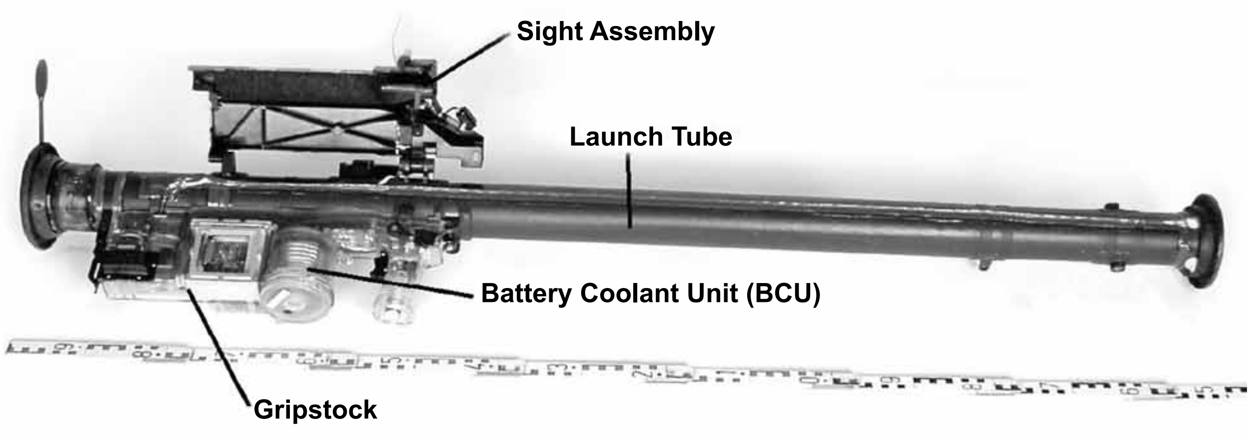
The following sections will consider each of these missile types—passive homing, command guided, and semi-active homing—in detail and introduce their individual components.

Passive homing

Passive homing MANPADS consist of three major separate elements: The missile in a launch tube, a detachable triggering unit called a ‘gripstock’, and a unit to supply power and cooling for the missile called the battery coolant unit (BCU). Terminologically, it is usual to differentiate between a ‘missile round’, consisting of missile and launch tube, and a ‘weapon round’, which is a fully functional MANPADS including gripstock and BCU.

MANPADS missiles, including spares, are not delivered as is, but are always contained in a launch tube. The launch tube includes the sight assembly for acquiring a target, sockets for gripstock and BCU (in some cases, notably the US Stinger displayed in Figure 3, the BCU is inserted into the gripstock, not the launch tube), and sometimes for an IFF (identification friend or foe) antenna. While the launch tubes are reusable in principle, they are not intended to be reloaded with a missile on the battlefield. Reloading is done—if at all—in a factory setting and requires both appropriate tools and expertise (Hughes, 2007).

Figure 3: Cutaway model of a Stinger weapon round



Source: Adapted from Klaus Holtkamp, First Sergeant, Technische Schule Landsysteme und Fachschule des Heers für Technik, Bundeswehr.

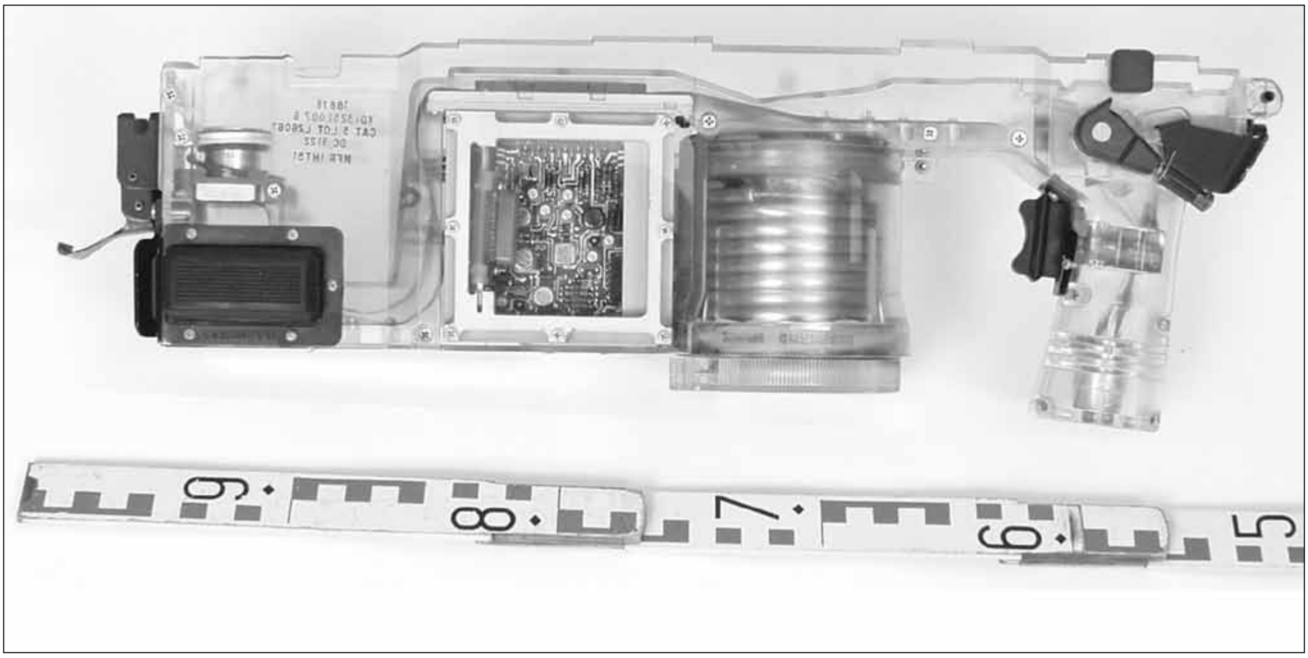
The gripstock forms the main interface between the MANPADS and the gunner. It consists of a handle with trigger and a housing, containing, depending on MANPADS type, targeting and other electronics. The gripstock is attached to the launch tube before launch and removed after the missile has been fired. Only the US Redeye, the first MANPADS ever built, had a gripstock which could not be removed.[3] ‘Redeye II’, which would later be renamed ‘Stinger’, already had a reusable gripstock to save costs and withhold crucial information from the enemy, as used launch tubes were often jettisoned after an engagement.

All three elements are integral parts of a complete MANPADS and the system is inoperable with any of them missing. The heart of the MANPADS, however, is the missile itself, which is a complex piece of engineering. The following section will look at each of its components from a technical perspective.

Seeker

In passive homing MANPADS, the seeker is the ‘eye’ of the missile. It is located at the front of the missile and is used to detect radiation emitted by the target. This radiation usually falls into the infrared (IR) spectrum, i.e. electromagnetic waves slightly longer than those of visible light. The human eye can typically detect wavelengths between 390 and 750 nanometers (nm), while IR radiation ranges from 750nm to 1mm (1mm=1000µm; 1µm=1000nm). IR radiation is emitted by warm or hot sources at different wavelengths depending on the temperature of the source.

Figure 4: Cutaway model of a Stinger gripstock with BCU



Source: Adapted from Klaus Holtkamp, First Sergeant, Technische Schule Landsysteme und Fachschule des Heers für Technik, Bundeswehr.

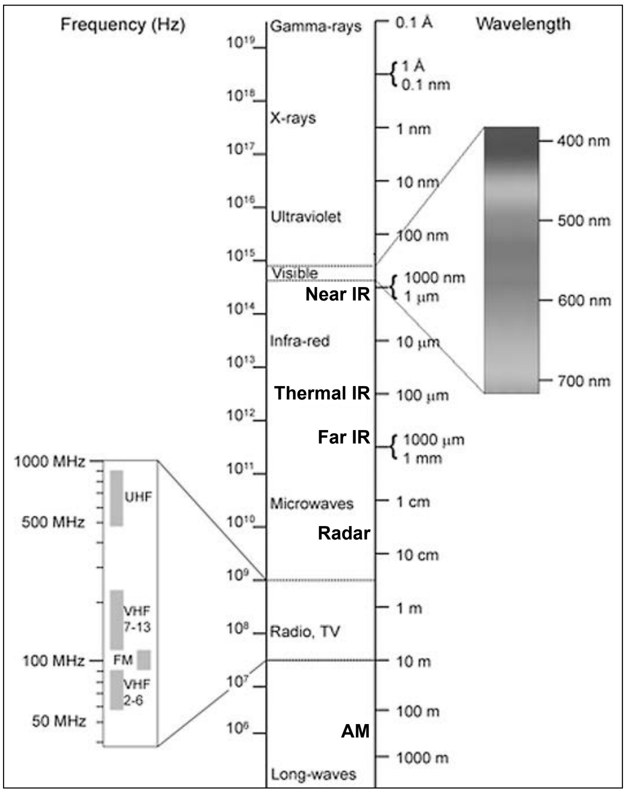
To provide energy for start-up and for cooling the infrared (IR) seeker, a BCU is attached to the launch tube before each launch. The BCU consists of a thermal battery that provides energy for the pre-launch phase of the missile and of a pressurized gas tank that cools the seeker head before missile launch. Once activated, it supplies power for a limited amount of time (about 30 to 90 seconds, depending on MANPADS type) and is then discarded. Typically, a missile is delivered with two BCUs, one main and one spare.

3 The early Redeye prototypes had a detachable gripstock as well, but it was later decided to switch to a ‘unitized’ system to increase the weapon’s reliability (Cagle, 1974, pp. 69–71).

Figure 5: Cutaway model of a Stinger battery coolant unit

Source: Adapted from Klaus Holtkamp, First Sergeant, Technische Schule Landsysteme und Fachschule des Heers für Technik, Bundeswehr.

Figure 6: The electromagnetic spectrum

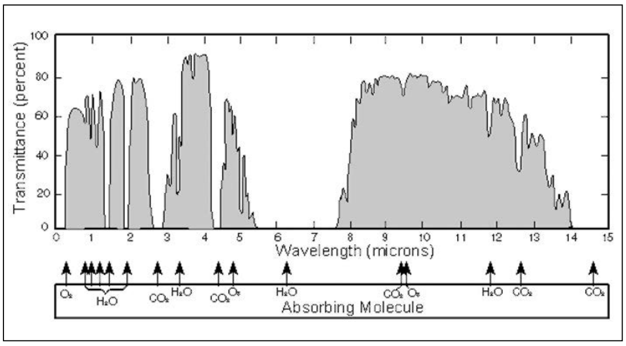


Source: User: Pennbag, Wikimedia Commons, CC-BY - SA 2.5

The seeker thus has to be able not only to detect IR radiation, but also to distinguish between different IR sources. Passive homing seekers can be categorized according to the range of the electromagnetic spectrum in which they seek or according to the size and shape of the area they scan.

The range of the electromagnetic spectrum in which a MANPADS seeker is designed to seek, is influenced on the one hand by the range of wavelengths in which the target emits radiation. On the other, it depends on the 'atmospheric windows', i.e. the ranges of electromagnetic radiation that are not easily absorbed, scattered or scintillated by the atmosphere, leading to a distorted or weak signal (Kopp, 1982).

Figure 7: Atmospheric windows



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Early models, as the Strela-2 or Redeye, scanned in just one range (or 'color') of the spectrum, initially in the 2–3µm band (Cagle, 1974, pp. 60, 199; Fiszer and Gruszczynski, 2002, p. 49). While this enables the seeker to distinguish between the IR radiation of the earth (around 10µm), the sun (around 3µm), and a fighter jet (2µm for the tailpipe, 4µm for the aft airframe and 4–8µm for the exhaust plume), it can easily be fooled by flares designed to radiate in this spectrum (Kopp, 1982). Also, early seekers were only able to detect the hot jet engine of the aircraft, limiting it to tail-chase engagements. Newer generation models switched to the 3–5µm range (Strela-3; Fiszer and Gruszczynski, 2002, p. 49), and later added a second 'band' of wavelengths to increase target discrimination. The latter are thus called dual band or two color seekers—using either two bands in the IR spectrum or a combination of IR and a band from a completely different spectrum, like ultraviolet (UV) radiation, millimeter waves (mmW) or visible light.

The seeker range is closely related to the material used to detect IR radiation. Early MANPADS used lead sulfide (PbS) detectors which were uncooled (Lyons, Long and Chait, 2006, p. 10; Yildirim, 2008, p. 40). Later models used indium antimonide (InSb) or mercury cadmium telluride (HgCdTe), which need to be cooled to around -200°C to achieve sufficient sensitivity, as well as cadmium sulfide (CdS), which covers part of the UV spectrum (Lyons, Long and Chait, 2006,

p. 10; Yildirim, 2008, p. 40; Kopp, 1982; Macfadzean, 1992, p. 243; Jane's, 2012b).

Another characteristic of IR seekers is the size and shape of the area they scan, as well as the pattern in which they scan it. The first generation of IR seeker heads had a rotating rectangular field of view (FOV) with a single detector element, leading to increasing inaccuracy in close proximity to the target (Kopp, 1982). The second generation of IR seekers used a conical scanning technique which eliminated these inaccuracies. Third generation seeker heads used a very narrow FOV that moved in a rosette pattern to improve the information available to the guidance system. This technique is also called 'quasi-imaging', as an image is assembled from several data points. The latest generation of seekers use imaging IR, which work similar to a digital camera. They are more easily capable of distinguishing between the target and countermeasures such as flares or decoys (see Chapter 6 for a discussion of countermeasures).[4]

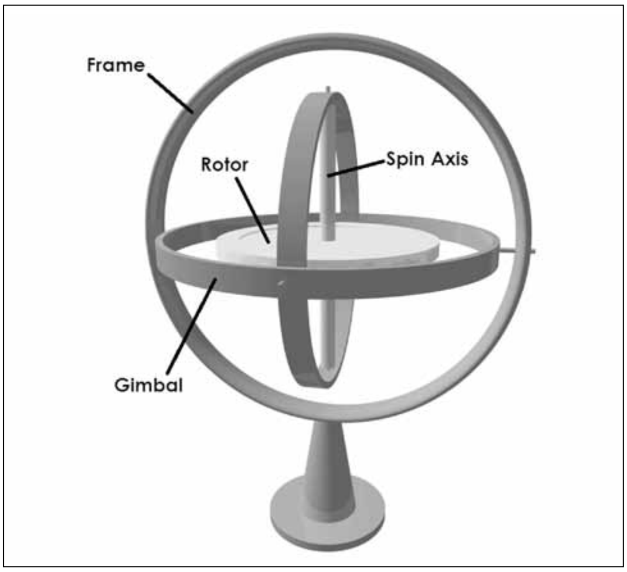
The central role of the seeker section in a MANPADS is highlighted by the fact that IR homing missiles are classified into different generations according to the seeker technology they employ. Table 5 provides an overview of the four generations of passive homing MANPADS and their defining characteristics.

As some of the intended targets of MANPADS are very maneuverable, it is impossible to keep them directly 'in front of' the missile. The seeker head, which has a very narrow FOV, must therefore be able to move independently from the missile's orientation. In order to achieve this, the seeker head is gimbal-mounted and stabilized by a gyroscope (see Figure 8). Once the rotor has gained sufficient momentum, the spin axis will remain stable regardless of gimbal movement.

Seeing that most missiles rotate at a frequency of between 10 and 20Hz (cf. Lyons, Long and Chait, 2006, p. 15; Fiszer and Gruszczynski, 2002, p. 47), precise gyro-stabilization is crucial to missile accuracy. The seeker head is covered by an IR-transparent dome to protect it from aerodynamic drag without distorting or degrading the incoming IR radiation.

[4] See Yildirim, 2008, p. 39f for a summarizing overview of scanning patterns, detector materials and seeker range of different generation MANPADS.

Figure 8: Schematic representation of a gyroscope



Source: Adapted from Wikimedia Common, Public Domain.

Guidance

The guidance section of the missile translates the information from the seeker as well as information on attitude and speed of the missile into concrete guidance commands for the steering section.

There are different algorithms available for this process, the most important one being proportional navigation (PN), a guidance method developed in the 1940s (Dyer, 2004, p. 16; Siuris, 2003, p. 194). As opposed to pure pursuit navigation, in which the missile keeps its velocity vector aligned with the line of sight (LOS) between missile and target, PN keeps the missile's acceleration proportional to the LOS turn rate (Siuris, 2003, pp. 166, 194; Frieden, 1985, p. 451). This effectively steers the missile to a predicted future position of the target. PN has proven so effective that it is used in virtually all modern guided missiles, even though in some cases in an altered configuration (Siuris, 2003, p. 161).

Conceptually, a MANPADS flight can be divided into the boost phase, the mid-course phase, and the terminal phase (Frieden, 1985, pp. 432–34, 54). The boost phase serves to get the MANPADS into a position with LOS to the target and to accelerate it to maximum speed. The mid-course phase usually is the longest part of the flight and serves to bring the missile as close to the target as possible. During the terminal phase, the missile is guided to a vulnerable part of the aircraft to maximize the chance of destruction. The terminal phase demands the highest performance

Table 5: Generations of IR homing MANPADS

MANPADS generation	Detector	Optical modulation	Characteristics
1st generation FIM-43 Redeye[5] SA-7A Strela-2 SA-7B Strela-2M HN-5A Anza Mk I CA-94	Uncooled PbS (lead sulfide) infrared (IR) detector	Spin-scan	• Tail-chase engagement only • High background noise • Increasing tracking error in close proximity to target • Vulnerable to flares • Single-shot kill probabilities between 0.19 and 0.53
2nd generation FIM-92A Stinger Basic Strela-2M/A SA-14 Strela-3 HN-5B Sakr Eye QW-1 FN-6 Anza Mk II Misagh-1 CA-94M	Cooled PbS, InSb (indium antimonide) or HgCdTe (mercury cadmium telluride) IR detector	Conical scan	• All-aspect capability • Reduced background noise • No tracking error • Some resistance to flares • Single-shot kill probabilities between 0.31 and 0.79
3rd generation FIM-92B Stinger POST FIM-92C Stinger RMP FIM-92E Stinger Block I SA-16 Igla-1 SA-18 Igla SA-24 Igla-S Grom-1 Grom-2 Mistral 1 Mistral 2 Chiron (Singung) QW-11 QW-18 QW-2 FN-16 Anza Mk III Misagh-2	Cooled dual channel IR or combined IR/UV detector	Rosette scanning (quasi-imaging)	• All-aspect capability • High resistance to flares • Better target discrimination under unfavorable conditions • Single-shot kill probabilities between 0.44 and 0.98
4th generation Kin-SAM Type 91 QW-4	Cooled imaging IR or combined IR/UV detector	Full imaging	• All-aspect capability • Very high resistance to flares and decoys • No data on single-shot kill probabilities available

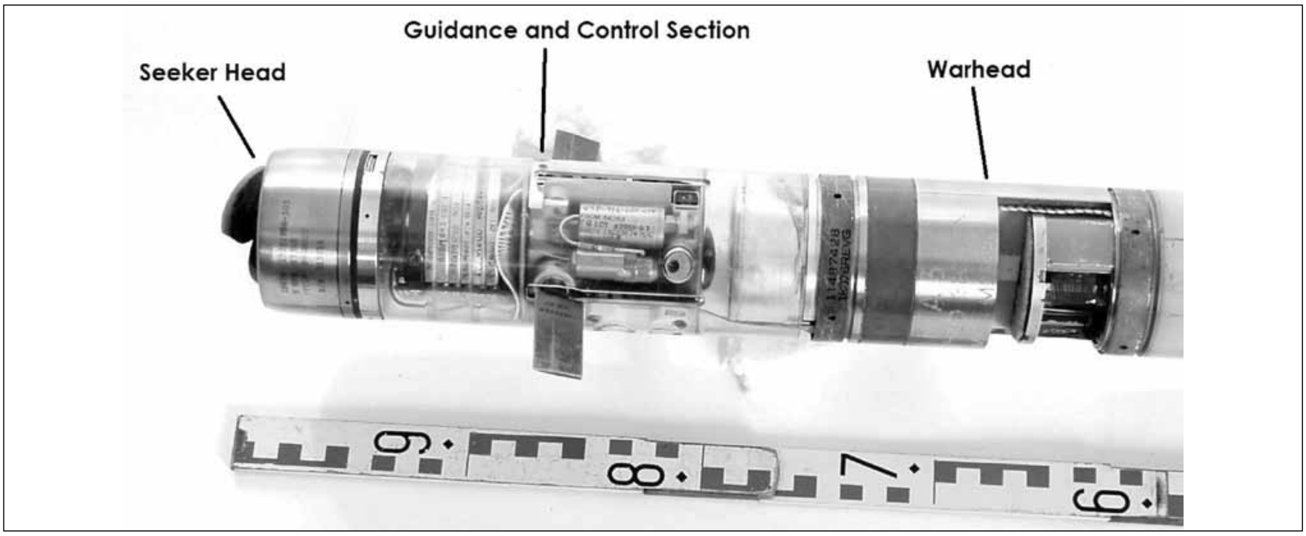
[5] From Block II onwards, the FIM-43 Redeye used a gas-cooled PbS seeker (Cagle, 1974, p. 129). As it retained spin-scan optical modulation, the missile can arguably be placed between generations 1 and 2.

of the guidance system. While this does not necessarily imply that different seeker mechanisms or even different guidance algorithms are used during each phase, most IR passive homing MANPADS do switch to a different guidance algorithm for the final phase of the flight. During 'terminal guidance', as this phase is called, the missile guidance algorithm is usually biased towards the airframe proper of the aircraft rather than the jet engine exhaust (Lyons, Long and Chait, 2006, p. 13; cf. Jane's, 2012c).

Control

The guidance computer inputs the information on the target's position relative to the missile into the guidance algorithm and computes the appropriate acceleration to correct the missile's current velocity vector. This information is then translated into concrete commands for the missile's steering elements. Usually, there is a set of stabilizing fins at the rear end of the missile and a set of steering canards in the front third, in the vicinity of the guidance section.

Figure 9: Stinger front section



Source: Adapted from Klaus Holtkamp, First Sergeant, Technische Schule Landsysteme und Fachschule des Heers für Technik, Bundeswehr.

As with the seeker head, missile flight control is a challenge due to the rapid missile roll. Quick mechanical implementation of the steering commands and precise information about the missile rotation are therefore crucial for steering the missile accurately. It comes as no surprise that Lyons, Long, and Chait have identified the improved servomechanism and dedicated laser gyroscope roll frequency sensor of later Stinger versions as key innovations to improve the MANPADS' accuracy (2006, pp. 12–13).

Warhead

The warhead is the element of the MANPADS that serves to destroy or render inoperable the target aircraft. In all cases, this is achieved by means of an explosive, although the missile's pure kinetic energy (mass*speed) can exert an enormous destructive force on the target on its own.

In principle, there are two main strategies of exerting force on the target: The first consists of the shock wave created by the explosion, as well as a large amount of small fragments of the warhead casing which are rapidly accelerated. This design is called blast fragmentation. In its most basic form, the force of explosion is not directed anywhere specific and results in a spherical shock wave. A more refined form is annular blast fragmentation, where the explosion is directed in a ring shaped form to increase its effectiveness. The majority of MANPADS rely on some form of blast fragmentation to achieve the destruction of the target (Gander, 2011). Some of the latest systems have combined annular blast fragmentation with a projectile consisting of a series of short metal rods that have been welded together at alternating ends, much like a folding rule, to expand into a large circular metal ring upon explosion, which then cuts into the aircraft. This setup is called continuous rod and is employed by the Russian SA-24 (9K338 Igla-S) and allegedly by the Chinese QW-3 (Macfadzean, 1992, p. 277; Gander, 2011; Jane's, 2012a; NA, 2007; Fiszer and Gruszczynski, 2002, p. 52). The second way of exerting force on the target is by use of a shaped charge, which focuses the energy of the explosion into a very small area. This technique is often used in armor-piercing warheads, where a cone-shaped piece of metal is condensed by the targeted explosion and heats up so quickly that it changes its aggregate state to plasma which then melts through armor plating. Only the Swedish RBS-70 MANPADS uses a shaped charge warhead, although the current Bolide missile combines both shaped charge and blast fragmentation in a single warhead (Jane's, 2011c).

To achieve the optimal destructive force of the warhead, it must be detonated at the right place at the right time. The guidance system is responsible for ensuring that the missile gets in a position that is as close as possible to the most vulnerable part of the target aircraft. A fuze then initiates the detonation of the warhead. Fuzes come in two types: proximity or impact. As the name says, a proximity fuze initiates detonation once a specific distance to the target is achieved, ranging from 0.5 (C-94M) to five (Igla-S) meters (Jane's, 2012d; Fiszer and Gruszczynski, 2002, p. 52). An impact fuze detects the first impact with the target and initiates detonation either immediately or after a time delay. The latter is utilized in cases where the missile can penetrate the target and explode there, as in the Starstreak missile projectiles, which reach a comparatively high maximum speed of between 1,020 and 1,150 meters per second (Jane's, 2011a; Jane's, 2012e; Gander, 2011). Most other MANPADS use an impact fuze or a combination of impact and proximity fuze.

Propulsion

As MANPADS are launched from the gunner's shoulder, it needs to be ensured that the latter is out of harm's way when the missile is accelerated to supersonic speed. All systems employ a dual stage propulsion system to solve this problem. First the missile is propelled out of the launch tube by a small launch (or eject) motor. The launch motor extinguishes before leaving the launch tube to protect the gunner and drops to the ground after some meters. After coasting a distance of between five and ten meters, depending on the MANPADS model, the flight (or sustainer) motor ignites and rapidly accelerates the missile to its maximum speed.

Conceptually, a rocket motor contains the fuel and an oxidizer, as opposed to a jet engine which uses air sucked in by the engine as an external oxidizer (Frieden, 1985, p. 465). Rockets can either run on liquid fuel, which is stored in a fuel tank separate from the oxidizer, or on a solid propellant which integrates these components. In most cases, MANPADS rocket motors use a composite solid propellant which consists of a binder, a fuel (for example aluminum), an oxidizer (usually ammonium perchloride), and a number of optional additives, such as a catalyzer or stabilizer. Generally, while the use of a solid propellant reduces the performance of the engine, its high density results in a more compact and lighter propulsion section which, in turn, leaves more room for other components, most notably the warhead (Thakre and Yang, 2010, p. 1). It is also very stable, which makes it easier to handle under battlefield conditions. The reactivity of the propellant depends on its exact composition and cannot be altered after production. MANPADS flight motors usually use two different 'grains' of propellant: a small amount of highly reactive booster propellant for rapid acceleration and a larger amount of less reactive sustainer propellant (cf. e.g. Jane's, 2011b; Jane's, 2012f; Jane's, 2011c; Jane's, 2012g). These burn in a combustion chamber and the exhaust is ejected through a nozzle at the rear to achieve forward propulsion.

While it is one of the simplest components of the missile, the rocket motor contributes most to size and weight of the missile. The rocket motor of the Redeye missile, for example, weighed 4.5 kg (10 lbs), with a total missile weight of 8.3 kg (18.3 lbs) (Cagle, 1974, p. 146). The Russian Strela-2M carries 4.2 kg of solid propellant fuel, while the missile weighs 9.6 kg (Jane's, 2011d).

Gripstock

The gripstock is the main interface between missile and gunner and mediates target acquisition and launch sequence (US Army, ND, p. 22). It enables the gunner to 'uncage' the seeker head (i.e. unlock it, so that it can move freely and acquire the target), start up the missile electronics and gyroscopes, initiate target lock, and trigger the missile launch. If desired and available, it also serves as an interface to the IFF interrogator. While gripstocks of early versions, namely the SA-7, merely contained the trigger mechanism, those of more advanced MANPADS have a more prominent role in the acquisition and launch sequence.

The gripstock has sometimes been classified as the actual weapon, while the missile round has been classified as 'merely' ammunition[6]. While this is a matter of definition, it is certainly true that the gripstock has a key function in a MANPADS system. Without it, a MANPADS missile cannot be fired and it is often shipped and stored separately from the missile rounds to limit the likelihood and impact of theft.

The missile round of a MANPADS is in many cases identical to those used in other, non-MANPADS setups. A prominent example is the Strelets multiple missile launcher for the Russian Igla-S missile, which is usually installed on a vehicle chassis. When, in the wake of the Libyan revolution, SA-24 Igla-S missiles which had been delivered with Strelets twin launchers were looted from government arms depots, they could not be used as a MANPADS as the gripstocks required to launch them were missing. This illustrates the key importance of tight gripstock control.

Other launch mechanisms

Classic gripstock setups are used in the American and Russian MANPADS series and all their descendants and copies. In addition, there are a number of passive homing MANPADS which use a different, bulkier launching mechanism in combination with a tripod. These include the French Mistral and the South Korean Chiron. This setup allows for assisted target tracking, as well as day and night sight devices. On the downside, these systems are substantially heavier and bulkier, and need to be transported by vehicle.[7]

Battery coolant unit

The battery coolant unit (BCU) is a disposable cartridge which is attached to either launch tube, gripstock or launcher unit, depending on the MANPADS model and it provides power to the system and cooling to the seeker head. Once activated, it provides power for start-up and launch of the missile for 30–90 seconds, again depending on missile type. If the missile has not been fired in this time period, the engagement will have to be aborted and the BCU will need to be replaced by a spare. With passive homing MANPADS, the BCU consists of two parts: a thermal battery and a tank with compressed gas for cooling.

The battery unit of the BCU is a so-called 'thermal' battery', even though 'thermally activated chemical battery' would be a more accurate term (see Guidotti and Masset, 2006). Like a conventional battery, it consists of an electrolyte and two electrodes. Unlike a conventional battery, however, the electrolyte is in solid state at room temperature and the battery is inert until the electrolyte is melted by a pyrotechnic device situated between the electrodes (Guidotti and Masset, 2006; Davidson, 2003; ASB Group, ND; Doughty et al., 2002, p. 357). The pyrotechnic device is activated by an impulse generator located in the gripstock (e.g. Stinger; Lyons et al., 2006, p. 11). Upon activation, the battery generates heat as a byproduct of the chemical reaction, leading to temperatures of more than 200°C at the surface of the BCU (US Army, ND, pp. 25, 54). The thermal battery supplies power for gyroscope spin-up, the activation of the on-board thermal battery or generator, eject motor ignition, as well as some less energy extensive pre-launch processes (Lyons et al., 2006, p. 11).

The second function of the BCU is to cool the infrared seeker head to its working temperature of around -200°C. This is achieved by the so-called Joule-Thompson effect, the rapid expansion of a gas, either argon (e.g. Stinger; see Jane's, 2012g), nitrogen (e.g. Strela-3, Igla, Igla-S; see Ochsenbein, 2008, p. 8) or compressed air (e.g. Mistral; see NA, ND).

Command guidance

Command guidance MANPADS share many components with their passive homing relatives. The missile itself, however, is lighter and cheaper, as the complicated seeker and guidance setups are outsourced to a launcher unit on the ground. A command guidance MANPADS thus consists of a missile round and a launcher unit, which is usually attached to a tripod assembly.

As with passive homing MANPADS, the missile is contained in a sealed, reusable launch tube. Together, these elements form a missile round. Once the missile has been fired, the now empty launch tube is replaced with a new missile round and the launch tube can only be reloaded in a factory setting. As the missile is guided from the ground, it does not require an on-board seeker. The weight and room that is

6 The United Nations' Report of the Panel of Governmental Experts on Small Arms, A/52/298, of 27 August 1997 defines in §26 "Portable launchers of anti-aircraft missile systems" as light weapons, while "Mobile containers with missiles or shells for single-action anti-aircraft and anti-tank systems" are defined as an ammunition (UN, 1997). The International Tracing Instrument of 8 December 2005, A/CONF.192/15, uses the same definition for launching mechanisms, while ammunition is not covered by the agreement (UN, 2005).

7 Jane's Land Warfare Platforms: Artillery & Air Defence 2012 states on the Mistral 1 that "[t]he basic assembly can be broken down into two 20 kg loads - the containerised missile and the pedestal mount with its associated equipment for carriage by the missile team commander and the gunner respectively. In operational use, the system will normally be transported in a light vehicle to the deployment area where it will be man packed to the firing site by the team."

freed up by the absence of a seeker section can be used for a more powerful rocket engine or warhead.

In addition to managing the missile launch, the launcher unit is also responsible for tracking the missile, calculating the required missile course, and transmitting guidance information to the missile.

Guidance architectures

The flight phase of command guidance MANPADS can be conceptually divided into two phases. First, the missile needs to be 'gathered' by the respective guidance mechanism, i.e. the missiles must be brought into the FOV of the gunner or into the guiding radio or laser beam (Kopp, 1989). Second, guidance information is transmitted to the missile until the target is hit. The way this is achieved has differed between models and generations of command guidance MANPADS.

In the early 1970s, the first two command guidance MANPADS were developed: the British Blowpipe and the Swedish RBS 70, which entered service in 1975 and 1976 respectively (Gander, 2011; Kopp, 1989). The Blowpipe was effectively a radio remote controlled missile, which was guided to the target solely by the gunner. Once the missile was automatically 'gathered' into the gunner's FOV, he had to track the missile and the target and steer the missile with the help of a thumb joystick. The RBS 70 used a 'beam riding' configuration, in which the gunner directs the missile to the target with the help of a laser beam. The gunner points the beam at the target and the missile uses sensors at the rear to ensure that it stays within the laser beam (Jane's, 2012h). This setup is semi-automatic, as the gunner only needs to track the target and keep the guiding beam aligned with it. The missile is again automatically 'gathered' into the laser beam and then continuously determines its position within the beam and corrects any deviations.

While both systems require very good operator training, the Blowpipe was so difficult to handle that even well trained gunners had a very low hit rate (Hillson, 1989; Freedman, 2005, p. 734). The Javelin, Blowpipe's successor, still stuck to command guidance but with automatic missile tracking. In practice, the gunner needed to only track the target and keep a stabilized aiming mark aligned with it. The system would track the missile via infra-red sensing, calculate the necessary guidance commands to keep the missile on the line of sight between gunner and target, and communicate them to the missile via a radio link (Kopp, 1989; Jane's, 2012i). With the introduction of the Starburst MANPADS in 1990, the radio guidance technique was abandoned in favor of a beam riding setup to avoid jamming (Jane's, 2012j). Since then, all modern command guidance MANPADS rely on laser beam riding.

Launcher unit

In command guided MANPADS, the launcher unit plays an even more crucial role than in passive homing models, as it is instrumental in guiding the missile to the target. Without it, the missile cannot be guided in any way. In fact, if the missile loses the guidance beam—and with it communication to the launcher unit—mid-flight, it will self-destruct (see e.g. Joshi, 2011b).

The launcher unit consists of two functional parts: the sighting unit and the control unit. The sighting unit enables the gunner to acquire and follow a target until impact. It consists of an optical sight, which is gyro-stabilized to facilitate target tracking, as well as an aiming mark, crosshair or aiming reticule, which the gunner needs to keep aligned with the target (Kopp, 1989). Modern command guided MANPADS, like the Starstreak II or RBS 70 NG, are also equipped with a thermal sight enabling engagements during night time (Saab Group, 2011; Thales Group, 2011). The control unit calculates initial lead angles and permits the gunner to follow the target with the help of a thumb joystick (Kopp, 1989).

The launcher unit is supported by a tripod stand, although there is a shoulder launched version of the Starstreak missile where the launcher unit is attached directly to the missile round.

Semi-active laser homing

In principle, semi-active laser (SAL) homing missiles resemble IR passive homing ones. There are, however, two major differences. First, the missile is equipped with a laser seeker head, which is immune to flares and highly resistant to jamming. It is also capable of locking on to low-signature targets, like attack helicopters or cruise missiles, at a much larger distance than a passive IR seeker. Second, the target needs to be illuminated by a ground-based laser rangefinder so that the missile can lock on to and track the target.

There is very little open source data available about how the technology is implemented in the Chinese QW-3 missile. According to Jane's (2012a) the QW-3 comes in an IR only, a SAL only, and a combined variant. It is not clear whether the SAL QW-3 is actually available in a MANPADS configuration or is only employed in a vehicle mounted multiple missile system, where it is designated FL-2000B. The fact that the SAL QW-3 is a two-stage missile with a weight of 23 kg suggests the latter, but it is not inconceivable that there is a tripod-mounted version as well.

Implications of technical aspects for MANPADS threat assessment

Seeker, guidance and control: In passive and semi-active homing missiles, the seeker and guidance section of a MANPADS is the single most important part of the missile to determine its accuracy. This does not only include the IR detector and guidance algorithm, but also other elements, such as the gyroscope that stabilizes the detector element and the roll frequency sensor that improves flight control. All other things being equal, the MANPADS with a more advanced seeker and guidance section will thus present a greater danger to civilian aircraft than earlier versions.

To reach maximum accuracy, the seeker head in particular must work under the right conditions. A gyroscope enables it to keep a stable position relative to the ground disregarding missile spin. A coolant keeps the temperature at around -200°C and an auto-tracker keeps the seeker centered on the target. As such, the seeker head is one of the most sensitive and vulnerable parts of an IR homing MANPADS and a forceful blow with a hammer to the seeker dome will render the missile useless.

First generation uncooled PbS seekers—apart from being easily distracted by background IR clutter—are only able to lock on to the engine of an aircraft, permitting tail-chase attacks only. Later generation seekers decrease interference of background radiation, allow to lock onto all aircraft surfaces and are all-around more reliable.

Warhead: Like all explosives, a MANPADS warhead is subject to degradation. Yet, as the warhead is a sealed unit, this happens very slowly. While even several decade-old warheads can continue to be functional, warhead degradation leads to a decrease in reliability of the MANPADS. Consequently, the older a MANPADS is, the higher the chance of warhead failure.

This trend is amplified by technological advances in warhead design. Early generation warheads, like that of the Russian Strela-2, had so little destructive power that not even a direct hit would reliably deal sufficient damage to down the target aircraft (Fiszer and Gruszczynski, 2002, p. 49). Later generations used more effective and more stable explosives as well as more functional warhead designs, leading to ever increasing single-shot kill probabilities (see Table 6 for details). Strategies to increase warhead lethality are manifold and include combining an increased area of impact with a proximity fuze, as employed by the Igla-S, as well as splitting the warhead into three separate darts to increase the hit probability, as used by the Starstreak MANPADS.

Rocket motor: Warhead and rocket motor rely on similar chemical processes, leading to some shared characteristics. The Russian Igla family (excluding the Igla-1E, which was mainly produced for export) even uses the leftover fuel as an additional explosive to enhance the destructive power of the warhead.

Like the warhead, a MANPADS rocket motor will slowly degrade, leading to an increase in failure and a decrease in consistency and uniformity of the reaction, both of which are crucial for accurate missile guidance.[8] Solid-fuel composition has changed and improved over time, with stabilizers being added to inhibit premature oxidation of the fuel. Consequently, later generation rocket motors are not only more reliable by design, but also by their lesser age and less advanced fuel degradation. In addition, one expert pointed out that the squib or electrical ignitors of both eject and sustainer motor need to be recharged or changed on a regular basis, which requires special equipment.[9]

Battery coolant unit: Thermal batteries are extremely robust and resilient against shock, extreme temperatures, and degradation. According to Guidotti and Masset, thermal batteries can withstand forces of 16,000 g and storage temperatures of between -55 and +75°C without significant degradation (2006, p. 1444). When protected from moisture and oxygen, they can stay operational for 25 years and longer (Guidotti and Masset, 2006, p. 1444). This makes them particularly suited for guided munitions and missiles, as well as space travel applications.

8 In an introductory presentation on MANPADS at a meeting of the Organization of American States on 8 March 2007, Chris Hughes of the United Kingdom Ministry of Defense stated regarding the rocket motor that "[...] when these things are manufactured the quality control of this part is very, very important because it has to burn evenly along the length of the motor to enable it to perform and fly in a straight line or as guided by the control" (7:38-7:54).

9 Personal email from a Mines Advisory Group (MAG) expert, 18 September 2012.

Nonetheless, the BCU has been identified as one of the weakest components in a MANPADS, concerning the life expectancy of the system, which indicates the overall robustness of MANPADS.[10] In addition, the short life span of the battery upon activation—a Strela-2 battery expires after 30 to 40 seconds—makes it harder for the gunner to conduct a successful engagement and may lead to a shortage of BCUs. Due to the high temperature of the activated thermal battery, the BCU has to be removed within minutes, or permanent damage to the BCU receptacle may render the weapon round inoperable (US Army, ND, p. 45).
Overall, the BCU clearly represents a limiting factor to successful attacks on civilian aircraft. It degrades more easily than other components, complicates the engagement process, can damage the MANPADS if handled improperly, and needs replacement once activated, even if the MANPADS cannot be fired.

IR vs. SACLOS: Contrary to the belief of some analysts (e.g. Wisotzki, 2007), command guidance MANPADS are not an evolution of, and therefore inherently better or more advanced than, passive homing ones. Rather, both have been used and developed in parallel, with newer models of both kinds, like the British Starstreak (command guidance) or Russian Igla-S (passive homing), being more capable than the early 'pioneers', like the British Blowpipe (command guidance) or US Redeye (passive homing) MANPADS.

Yet it is true that command guidance missiles of the beam riding type are immune to most currently available countermeasures, the majority of which have been developed to confuse passive homing missiles, as well as jamming devices which aim to disrupt communication between gunner and missile. While this makes them more dangerous for military targets, this quality is less relevant for civilian aircraft, most of which are not equipped with countermeasures anyway, so that passive homing missiles are not at a disadvantage against such targets. Yet, this point does require an important qualification: The analysis of attacks on civilian aircraft in Chapter 1 shows that MANPADS attacks have occurred near exclusively in active war zones. While it is not feasible to equip civilian airplanes worldwide with IR countermeasures, a focus on areas of armed conflict may reduce the risk of successful MANPADS attacks drastically. This is especially relevant in light of the finding that there is no evidence for attacks on civilian aircraft with command guided systems (see Chapter 1) and the near ubiquity of IR guided MANPADS worldwide (see Chapters 3 and 4).

Currently, however, only a very small amount of civilian airplanes is equipped with systems to counter the threat of MANPADS attacks. Therefore, for civilian airplanes the pure hit probability of a MANPADS is the deciding factor, assuming that the missile is fully functional and the gunner is familiar with its handling. All modern MANPADS, regardless of the type, have demonstrated a very high hit probability in testing (see Table 6), though many have not been used on the battlefield.

Some additional factors need to be considered regarding MANPADS performance:

Weather conditions: A weakness of laser beam riding missiles is their dependence on clear weather conditions, as water particles diffuse the laser beam and the gunner needs to be able to track the target visually. Even very advanced systems, like the British Starstreak II and the Swedish RBS 70 Bolide MANPADS suffer from this problem. Only the very latest RBS 70 NG operates independent of weather conditions.

Launch mechanism: Launch mechanisms, i.e. gripstocks and tripod-mounted launch units, have become more complex and their role in MANPADS has increased in importance. One expert reported that improvised gripstocks for SA-7 MANPADS have been found in Afghanistan.[11] Second generation and more recent IR homing MANPADS, however, are very unlikely to be fired without a gripstock. While a theoretical possibility of use with an improvised launching mechanism remains for IR homing MANPADS, a command guided MANPADS is completely useless without the launcher unit and it will self-destruct if communication with the launcher unit is lost during missile flight.

Ease of use: Even for early generations of IR homing missiles, operators were able to learn basic maneuvers relatively quickly. While a large number of hours is necessary to qualify as a MANPADS gunner in a military context, this time is substantially shorter from a purely practical perspective. One expert of the German Armed Forces estimated that a 30 minute introduction would be sufficient to perform the basic operations of a Stinger MANPADS. Precise and reliable operation of a MANPADS does, however, require a much larger amount of training. Command-guided MANPADS, on the other hand, gained a reputation of being very hard to operate, even with a good amount of training. The abysmal combat performance of the Blowpipe MANPADS, both in Afghanistan and in the Falklands

[10] Personal email from a Mines Advisory Group (MAG) expert, 18 September 2012.

[11] Personal email from a Mines Advisory Group (MAG) expert, 18 September 2012.

Table 6: Single-shot kill probabilities of different MANPADS.[12]

MANPADS	Claimed hit probability	Actual hit probability
Strela-2		0.19–0.25 (Fiszer and Gruszczynski, 2002, p. 49)
Strela-2M		0.22–0.25 (Fiszer and Gruszczynski, 2002, p. 49)
Strela-2M/A	0.42–0.45 ("Advantages when compared to the standard Strela-2M warhead are: […] A 0.2 per cent increase in the single-shot kill probability figure" (Jane's 2011e)[13])	
Strela-3		0.31–0.33 (Fiszer and Gruszczynski, 2002, p. 49)
Igla-1 (SA-16)		0.44–0.59 (Fiszer and Gruszczynski, 2002, p. 49)
Igla (SA-18)	0.45–0.63 (Ochsenbein, 2008 p. 7)	
	0.45–0.65 (Fiszer and Gruszczynski, 2002, p. 49)	
Igla-S (SA-24)	0.5–0.75 (Fiszer and Gruszczynski, 2002, p. 49)	
Stinger Basic (FIM-92A)		0.79 (Kuperman, 1999, p. 246)
Redeye (FIM-43)		0.403–0.53 (Cagle, 1974, p. 147)
FN-6/HY-6	0.7 (Jane's, 2011f)	
FN-16/HY-6	>0.8 (Jane's, 2012k)	
QW-3 (FL-2000B)	>0.85 (Richardson, 2003)	
Mistral 1	"very high" (Jane's, 2011g) 0.98 (Joshi, 2011a)	
Starstreak I	0.96 (Jane's, 2012e)	
RBS-70	0.93 (Pike, 2000)	
Chiron	0.9 (Jane's, 2012l)	

War, was a key factor for this reputation. In the past decades, however, command guided MANPADS have introduced a range of mechanisms that assist the gunner in operating the system, notably a stabilized sight and target auto-tracking. As a consequence, the gap between IR homing and command guided MANPADS regarding ease of use has become significantly smaller and other aspects, like mobility, price, and availability, have gained in importance.

Exploiting aircraft vulnerabilities: While an IR guided missile will always home in on the engine, a command guided missile can, in theory, be steered towards a more vulnerable part of the airpart. This does, however, require a very well trained gunner and adds to the existing difficulties in operating a command guided missile.

Overall, command guided MANPADS are thus still at a disadvantage compared to their IR homing relatives, even though the difference has decreased enormously. They are more difficult to use, more dependent on clear weather conditions, and cannot be used without the appropriate launch mechanism. Their main advantage, immunity to countermeasures, is of little relevance in the context of attacks on civilian aircraft which are not equipped with such mechanisms in the

12 Note that these numbers need to be taken with a grain of salt and are not fully comparable. It is often unclear under which circumstances and against which targets the hit probability was measured. The table serves merely as an illustration of the orders of magnitude of different MANPADS' hit probability.

13 As a 0.2 percent increase would be insignificant, we assume that the author actually means an increase of 0.2 in the kill probability, which would equal an increase of 20 percentage points.

first place. Their ability to target the most vulnerable part of an aircraft depends on a well trained operator.

System weight and setup: A number of MANPADS are noticeably bulkier and heavier than others, making them more difficult to smuggle and transport. They employ a setup where a launcher unit, attached to a tripod, is used rather than a gripstock. While the latter weigh between 15 and 19 kg, the former range from 24 to 35 kg. They need to be carried by a team of two or three people and require more time to set up than those of the gripstock variety. Overall, this makes them slightly less desirable for a clandestine attack on a civilian aircraft. MANPADS of this category include the RBS 70, Mistral I and II, Chiron, as well as the Lightweight Multiple Launcher (LML) version of the Starstreak.

Semi-active laser guidance: SAL MANPADS face similar restrictions to command guided missiles: they are more difficult to operate, heavier and bulkier than IR homing MANPADS, and are impossible to operate without a complete system. As such—apart from the near complete absence of such weapons from the world market—they do not represent the weapon of choice for an attack on a civilian aircraft.

Repair and spare parts: As many of the MANPADS in circulation are several decades old and often stored in less than ideal conditions, failure of or damage to parts of a MANPADS are increasingly likely to occur. In addition, MANPADS that were looted from state stockpiles or other sources are often incomplete, lacking either gripstock, BCU, or both. The question thus arises, whether a non-state armed group can realistically repair a damaged MANPADS with spare parts or with improvised craft components.

MANPADS missiles are compartmentalized and all components can in principle be replaced. This, however, is not a trivial enterprise without expert know-how and outside a factory setting. Even removing the missile from the launch tube requires the loosening of a number of connections between the tube and the missile which transfer power, information, and the coolant to the missile before launch. Another problem is aligning the components neatly after replacement. At production, each missile is tested electronically for imbalances. This is important, as the missile rotates at high speed and needs to be able to withstand high-g maneuvers. Outside a factory setting this level of precision is hard to achieve.[14]

In principle, however, all missile parts can be replaced. According to one expert, the seeker and the rocket motor's electrical ignitors are the most sensitive parts and are likely to fail first.[15] Given the relatively low prices of MANPADS on the black market (see Chapter 3; cf. Silverstein and Pasternak, 2003), complicated and potentially dangerous repairs are likely as a last resort only, while acquisition of a functional MANPADS seems more feasible and likely.

Conclusion

From the above analysis, the following conclusions can be drawn regarding the threat of MANPADS for civilian aviation:

- Overall, MANPADS are very durable and can be functional after decades. Some components—including warhead, rocket motor, electrical ignition, and thermal batteries—degrade more quickly than others, leading to a decrease in reliability with greater system age.
- The seeker and guidance sections contribute most to a MANPADS' accuracy, but they are also the system's most sensitive elements. From a purely technical perspective, later generation MANPADS with their higher hit probability pose a higher risk to civilian aircraft. Destroying the seeker head of an IR passive homing or semi-active laser homing MANPADS will make the system unusable.
- IR passive homing MANPADS continue to be easier to use as they require less training and have a higher chance of a successful engagement than command guided MANPADS. Still, the latter have closed the gap significantly and in the not too distant future may be as easy to use as passive homing MANPADS.
- Tripod-mounted MANPADS are less mobile and more difficult to transfer clandestinely. Shoulder-fired systems pose a greater danger to civilian aviation.
- While repair or replacement of nearly all components is possible in theory, the technical difficulties of such a procedure make it very unlikely. Increasing complexity of later generation MANPADS, as well as low black market prices of complete systems, further decreases the likelihood of 'craft MANPADS'.

[14] Hughes emphasized this point, stating: "I would like to make the point that this is not the sort of thing that a terrorist or an insurgent can manufacture in a workshop in his garage, in his basement, and put one of these things together. It's a very, very technical production." (2007, 6:03–6:17).

[15] Personal email from a Mines Advisory Group (MAG) expert, 18 September 2012.

Michael Ashkenazi and Jan Grebe

3 MANPADS transfers

Background

While the demand for anti-air point defense and VSHORAD (Very Short-range Air Defense) has been growing in the period since the 1970s, the complexity of manufacturing MANPADS is such that only a limited number of manufacturers have the necessary technology to produce these weapons. A direct result of this basic fact is a lively trade in MANPADS from manufacturing countries to many of the world's armed forces. The objective of this chapter is to highlight the main features of this trade, concentrating on what we know of state-to-state and other transfers, keeping in mind that many transactions are either secret, for reasons of military security, or under the table, as for example supplies to Non-State Armed Groups (NSAGs).

It is necessary to keep in mind that reports of receipts of MANPADS by destination are not always equivalent to reports from originating nations. Either or both parties to a transaction may not report, or even actively hide, any transactions, so that it is difficult to piece together the full picture with a desired level of reliability. What characterizes MANPADS transfers in general are differences of scale. Some transfers are of less than twenty units, others are of thousands.

There is often no clarity about what is being transferred: missiles alone (in their tubes, which assumes the recipient has gripstocks) or missiles and gripstocks, effectively, ready to fire systems. Judging from manuals and instructional material (e.g. US Army, 1984), a relationship of one gripstock to four missiles seems reasonable (two weapon rounds ready to use and two missile rounds still boxed), though this often depends on specific posture (see below). In some cases, a purchaser may purchase more missiles than gripstocks to keep a stock for emergencies.

Three patterns of purchase can also be identified. Western states and those who ally themselves with European or US patrons tend to choose Western manufactured weapons whereas former Soviet allies tend to prefer Russian weapons (see Table 7 for numbers). Developing nations tend to acquire a mix of MANPADS from different sources. It is not always clear what motivates a particular purchase: pricing, policy, or tactics, export restrictions, or political *quid pro quo*.

One complex issue that needs to be considered is the conversion of systems mounted on a vehicle to MANPADS configuration. For example, many Mistral configurations are designed for mounted, not dismounted, use. Can such missile tubes be used with a portable launching mechanism? The Russian answer is unequivocally 'no' (Litovkin, 2005) though at least several experts we have interviewed indicate such conversion is possible but unlikely.

Value of trade

Large purchases of MANPADS tend to be characteristic of states with weak air forces that compensate for such weakness by bolstering their ground-based anti-aircraft capabilities. A further variable is military doctrine: Soviet/Russian military doctrine emphasizes anti-aircraft defense at all levels down to the battalion level of regular infantry, artillery and armored units which incorporate MANPADS in their Table of Organization. US doctrine emphasizes MANPADS units for all maneuver divisions. Other Western doctrines tend to use MANPADS for special units and circumstances. Soviet and current Russian doctrine emphasize mobile anti-aircraft protection for high value artillery and headquarter targets. Dependents and allies tend to follow the pattern of their patron, with many reservations. This has implications in terms of the numbers of MANPADS and transaction value, depending on the relevant military's doctrine.

In addition to the missiles themselves, MANPADS transfers often include training aids, ranging from simple dummy missiles to complex computerized planetarium-type training buildings. The availability of these training aids can indicate the importance of these weapons in the particular mix of weapons an armed force requires. This in turn implies that the economic value of any MANPADS transfer is misleading, since ancillary services, as training, testing, and maintenance (and possibly the political advantage gained), may account for a significant part of the deal.

Black market

In addition to the legal trade, there is, apparently, an extensive black market for MANPADS, here defined as any MANPADS transaction between non-state actors. Prices on the black market vary extensively (Schroeder and Buongiorno, 2010b. Silverstein and Pasternak, 2003, give slightly lower prices overall). Authenticated price quotes range from a low of around US $5,000 for a first generation Strela-2, up to US $160,000 for Stingers and Igla-S. Given the high volatility of this market, prices should be expected to be highly flexible depending on the needs and pockets of the buyers. It seems that such transactions tend to involve small numbers of individual units, so the total monetary value (however costly individual items might be) is not too high. At the individual level, of course, MANPADS represent highly attractive merchandise for unscrupulous merchants, whose ultimate clients may be NSAGs or even state entities under embargo, who may settle for what they can get or other less affluent states (see Box 4 "The Mombasa attacks and the Yemeni arms markets"). A further effect on prices on the black market is the persistent attempt of the US government to purchase black market weapons for destruction. Claimed successes include the purchase and destruction of over 1000 MANPADS in Yemen (Seche, 2009).

It should be kept in mind that insofar as the black market is concerned, it is the quality of the weapons sold rather than the volume of sales that is at issue. Individual units of high-performance MANPADS (generation three and above) in the hands of terrorist constitute a significant hazard to civilian transport. They are consequently in high demand and priced accordingly. Older Strela family missiles have a mixed record against jet airplanes and are thus much cheaper.

MANPADS, as an economic segment, represent a minor income stream for manufacturing and trading nations. Clearly, price flexibility is not purely an economic matter, but depends more on political factors. What seems to be of more crucial importance than sales from manufacturing countries, are the black and gray markets. Within that segment, sales of obsolete stocks by a purchaser are particularly problematic, as the Ukrainian and Venezuelan cases show.

Destination picture

This section describes the transfer picture from the destination side. Given that not all transactions are confirmed publicly, we are unable to state that these are the only transactions that have taken place. However, in several instances we are able to identify transactions and subsequent effects. At least 102 countries have or have had MANPADS in their inventories. The examples dealt with here in some detail were selected as representative cases.

Based on the SIPRI Arms Transfer Database (SIPRI, 2012), Table 7 presents all MANPADS transfers in the period between 1990 and 2010. The Table does not include missiles that were delivered in a vehicle or ship-mounted, non-MANPADS configuration. It also disregards technology transfer and licensed produced systems, as these are dealt with in a separate section below.

Table 7: MANPADS transfers between 1990 and 2010

Recipient	Supplier	MANPADS	Year	No.	Comments
Afghanistan/ NA	Russia	Igla-1/SA-16 Gimlet	2000	100	
Angola	USSR	Igla-1/SA-16 Gimlet	1990	150	
Armenia	Russia	Igla/SA-18 Grouse	1996	200	Ex-Russian; illegal transfer; transfer also includes 40 launchers
Australia	Sweden	RBS-70 Mk-3 Bolide	2007	150	SEK150 m (US $18 m) deal (part of SEK600 m 'Project Land-19 Phase-6')
Austria	France	Mistral	1996	500	Part of US $129 m deal (incl. euro 87 m for RAC; offsets US $344 m) incl. 22 RAC radars and MITS-2 night sights; deal incl. also 63 or 76 launchers
Azerbaijan	Ukraine	Strela-3/SA-14 Gremlin	2008	18	Ex-Ukrainian
Bangladesh	China	HN-5A	1992	50	
		HN-5A	2001	21	HN-5JA1 version
		QW-2	2007	250	

Recipient	Supplier	MANPADS	Year	No.	Comments
Belgium	France	Mistral	1994	290	Deal incl. also 24 ATLAS launchers
Bolivia	China	HN-5A	1995	30	
Botswana	Russia	Igla-1/SA-16 Gimlet	1996	50	
	UK	Javelin	1992	25	Deal also incl. 5 launchers
Brazil	Russia	Igla/SA-18 Grouse	1994	112	Deal also incl. 56 launchers
		Igla-S/SA-24	2011	250	
Brunei	France	Mistral	1999	48	FFR200 m (US $30 m) deal
		Mistral	2006	24	
Burkina Faso	Ukraine	Strela-3/SA-14 Gremlin	1999	10	Probably ex-Ukrainian; designation uncertain (reported as 'SAM'); possibly delivered to Liberia via Burkina Faso
Burundi	Unknown country	Strela-2/SA-7 Grail	1990	305	
Cambodia	China	FN-6	2009	50	Possibly FN-16 version
Canada	UK	Javelin	1992	1100	
		Starburst	1992	100	
Chile	France	Mistral	1997	750	Deal incl. also Mygale SAM system with ASPIC launchers and MANPADS launchers
Cuba	USSR	Igla-1/SA-16 Gimlet	1990	100	Incl. SA-N-5 version
Cyprus	France	Mistral	2005	200	
Czech Republic	Sweden	RBS-70	2007	90	SEK204 m (US $29 m) deal (incl. 15-16 launchers); offsets 100%
Denmark	USA	FIM-92 Stinger	1996	840	US $150 m deal
DRC (Zaire)	Unknown country	Strela-2/SA-7 Grail	1995	10	
Ecuador	China	HN-5A	1994	72	Deal incl. also 30 launchers
	Russia	Igla-1/SA-16 Gimlet	1998	222	US $14 m deal
		Igla/SA-18 Grouse	2009	50	
Egypt	USA	FIM-92 Stinger	1991	100	Aid; for use in 1990-1991 Gulf War; FIM-92A version
		FIM-92 Stinger			Delivery 2012
El Salvador/ FMLN	Nicaragua	Strela-2/SA-7 Grail	1990	100	Ex-Nicaraguan; aid
		Igla-1/SA-16 Gimlet	1990	10	Supplier uncertain
		Strela-3/SA-14 Gremlin	1990	45	Ex-Nicaraguan; aid

Recipient	Supplier	MANPADS	Year	No.	Comments
Eritrea	Russia	Igla/SA-18 Grouse	1995	50	
		Igla/SA-18 Grouse	1999	200	
Estonia	France	Mistral	2009	100	Part of euro 60 m deal; Mistral-2 version
Finland	Sweden	RBS-70 Mk-3 Bolide	2010	200	SEK600 m (US $85 m) deal
	USSR	Igla/SA-18 Grouse	1990	100	
Georgia	Poland	Grom-2	2007	100	Incl. 30 launchers
Greece	USA	FIM-92 Stinger	1994	1500	US $124 m deal (incl. 500 launchers)
		FIM-92 Stinger	2006	432	US $48 m deal; for ASRAD SAM systems from FRG
		FIM-92 Stinger	2004	200	Part of US $89 m deal (for 1007 missiles for Greece, Italy and UK)
India	Russia USSR	Strela-2/SA-7 Grail	1994	250	Incl. SA-N-5 naval version; probably ordered from Soviet Union and delivered from Russia after break-up of Soviet Union
		Igla/SA-18 Grouse	2003	2250	US $32-50 m deal
		Igla/SA-18 Grouse	2011	200	US $26 m deal; delivery 2008–2012
		Strela-2/SA-7 Grail	1991	2500	Incl. SA-N-5 naval version; probably more delivered from Russia after break-up of Soviet Union
		Igla-1/SA-16 Gimlet	1991	2500	
Indonesia	China	QW-3	2007	130	Incl. for Indonesian UN peacekeeping force in Lebanon
		QW-3	2009	80	Part of US $35 m deal; for TD-200B SAM system
		QW-3	2010	15	
Iraq	USSR	Igla-1/SA-16 Gimlet	1990	1000	
Ireland	Norway	RBS-70	2008	20	Ex-Norwegian
Israel	USA	FIM-92 Stinger	1996	344	
Italy	USA	FIM-92 Stinger	2002	50	Probably US $10 m deal; possibly for A-129 helicopters; status uncertain
		FIM-92 Stinger	2004	200	Part of US $89 m deal (for 1007 missiles for Greece, Italy and UK)
Japan	USA	FIM-92 Stinger	1991	232	FIM-92A version
Jordan	Russia	Igla/SA-18 Grouse	2001	100	

Recipient	Supplier	MANPADS	Year	No.	Comments
Kuwait	Egypt	Strela-2/SA-7 Grail	1990	36	Sakr Eye version
	UK	Starburst	1995	250	GBP50 m (US $80 m; incl 50 launchers)
Laos	Russia	Igla-1/SA-16 Gimlet	2005	50	Designation uncertain; deal incl. also 25 launchers
Latvia	Sweden	RBS-70	2007	102	SEK185 m (US $28 m) deal (incl. ex-Swedish launchers as aid)
Lebanon/ Hezbollah	Iran	Strela-2/SA-7 Grail	1997	100	Ex-Iranian; aid
Lithuania	Norway	RBS-70	2005	260	Ex-Norwegian; part of LTL135 m (US $50 m) aid; deal incl. also 21 launchers
	USA	FIM-92 Stinger	2007	54	US $31 m deal (incl. 8 launchers)
Macedonia/ NLA	Unknown country	Strela-2/SA-7 Grail	2001	10	
Malaysia	China	FN-6	2009	64	
	Pakistan	QW-1 Vanguard	2003	160	US $13 m deal; Anza-2 version
	Russia	Igla-1/SA-16 Gimlet	2002	382	US $48 m deal (incl. 40 launchers)
	UK	Javelin	1991	60	Deal also incl. 12 to 48 launchers; status uncertain
		Starburst	1997	504	
Mexico	Russia	Igla/SA-18 Grouse	2002	30	US $2.1 m deal (incl. 5 launchers); to protect off-shore oil installations
Myanmar	Bulgaria	Igla-1/SA-16 Gimlet	1999	100	Supplier uncertain
	China	HN-5A	1992	200	
Myanmar/ MTA	Cambodia	Strela-2/SA-7 Grail	1994	10	Illegal deal; sold via Singaporean dealers; several more confiscated in 1995 by Thailand while being delivered
New Zealand	France	Mistral	1998	27	Part of NZD23 m (US $16 m) deal (incl. 12 launchers)
Nicaragua	El Salvador / FMLN	Strela-3/SA-14 Gremlin	1991	17	Returned by FMLN to Nicaragua after peace
Oman	UK	Javelin	1990	280	
Pakistan	France	Mistral	1995	100	
Peru	Bulgaria	Igla-1/SA-16 Gimlet	1996	417	Deal also incl. 56 launchers
	China	FN-6	2010	15	US $1.1 m deal
		QW-11			
	Nicaragua	Igla-1/SA-16	2009	10	QW-18 version
		Gimlet	1993		
				216	Ex-Nicaraguan; deal incl. also 72 launchers
	UK	Javelin	1995	200	No. delivered could be up to 500
Portugal	USA	FIM-92 Stinger	1996	30	

Recipient	Supplier	MANPADS	Year	No.	Comments
Qatar	France	Mistral	1996	500	Incl. for Vita FAC; deal incl. also MANPADS and SADRAL launchers
Saudi Arabia	France	Mistral	1992	700	
		Mistral	2010	1000	euro 500m deal; for National Guard
	USA	FIM-92 Stinger	1990	200	Delivered in reaction to Iraqi 1990 invasion of Kuwait (Gulf War)
Serbia & Mont.	Kazakhstan	Igla-1/SA-16 Gimlet	1995	226	Ex-Kazakh; deal incl. also 57 launchers; illegal deal
Sierra Leone/RUF	Ukraine	Strela-2/SA-7 Grail	1999	5	Designation uncertain; supplied to Burkina Faso but from there illegally transferred to RUF
Singapore	France	Mistral	1996	500	Deal incl. also MANPADS and SIMBAD (naval) launchers
	Russia	Igla/SA-18 Grouse	1999	350	Deal incl. also 30 launchers; no. could be 440; possibly assembled in Singapore
Slovakia	Russia	Igla/SA-18 Grouse	2010	120	
Slovenia	Russia	Igla-1/SA-16 Gimlet	2003	4	
Somalia/SNA	Eritrea	Strela-2/SA-7 Grail	1998	50	
Somalia/UIC	Unknown country	Igla/SA-18 Grouse	2006	6	Allegedly from Eritrea
South Africa	UK	Starstreak	2005	96	US $13 m deal (part of US $117 m 'Ground Based Air Defence System (GBADS) Phase-1' programme)
South Korea	France	Mistral	1997	984	US $180 m deal (offsets 25%); deal also incl. 130 MANPADS launchers
		Mistral	2000	1742	US $300 m deal
	Russia	Igla-1/SA-16 Gimlet	1996	50	Part of 'Bul-Gom' or 'Red Bear-1' deal worth US $209 m (payment of Russian debt to South Korea)
Spain	France	Mistral	1997	840	US $154 m deal (incl. 108-200 launchers; offsets 50%)
Sri Lanka/LTTE	Cambodia	Strela-2/SA-7 Grail	1995	25	Supplier uncertain
	Unknown country	Strela-3/SA-14 Gremlin	1998	5	
Sudan	China	FN-6	2006	50	
Syria	Belarus	Igla/SA-18 Grouse	2003	300	US $30-100 m deal; supplier uncertain
		Igla/SA-18 Grouse			
Taiwan	USA	FIM-92 Stinger	2001	728	US $180 m deal (incl. 61 launchers)
		FIM-92 Stinger			US $9.9 m deal; Stinger Block-1 version
Tanzania	Unknown country	Igla-1/SA-16 Gimlet	1996	50	

Recipient	Supplier	MANPADS	Year	No.	Comments
Thailand	Russia	Igla-S/SA-24	2010	36	US $4 m deal
	Sweden	RBS-70	1997	15	US $4 m deal (incl. 3 launchers); RBS-70 Mk-2 version
		RBS-70	2005	75	
Turkey	Germany (FRG)	FIM-43C Redeye	1994	300	Ex-FRG; aid
	USA	FIM-92 Stinger	1992	469	US $33 m deal (incl. 150 launchers)
Turkey/PKK	Unknown country	Strela-2/SA-7 Grail	1997	10	
United Arab Emirates	France	Mistral	1994	500	For Abu Dhabi; deal incl. also ATLAS launchers
	Russia	Igla-1/SA-16 Gimlet	1999	400	For Abu Dhabi; may include SA-18 version
Uganda/LRA	Unknown country	Strela-2/SA-7 Grail	2002	5	
United Kingdom	Russia	Igla-1/SA-16 Gimlet	2006	31	
	USA	FIM-92 Stinger	2004	100	Part of US $89 m deal (for 1007 missiles for Greece, Italy and UK)
United States	Afghanistan Mujahideen	FIM-92 Stinger	1992	10	Delivered in 1980s as aid to Mujahideen and bought back after Soviet withdrawal from Afghanistan
	Angola	FIM-92 Stinger	1992	250	Delivered in 1980s as aid to UNITA and bought back after peace agreement in Angola
					Probably for evaluation and training
	Ukraine	Igla/SA-18 Grouse	2003	29	Probably for evaluation and training Ex-Ukrainian
		Igla/SA-18 Grouse	2006	128	Ex-Ukrainian
		Strela-3/SA-14 Gremlin	2006	33	
		Igla-1/SA-16 Gimlet	2006	295	
Venezuela	France	Mistral	2002	100	
	Russia	Igla-S/SA-24	2010	2000	Deal incl. also 200 launchers
	Sweden	RBS-70	1991	200	
		RBS-70	2001	200	Part of SEK375 m (US $54 m) deal
Vietnam	North Korea	Igla-1/SA-16 Gimlet	1997	100	
	Russia	Igla/SA-18 Grouse	2002	50	
Yemen	Russia	Strela-2/SA-7 Grail	1994	100	Ex-Russian; SA-7b version; launchers delivered from Bulgaria

Source: Adapted from SIPRI, 2012.

Overall, transfers totaled 36,826 missiles (not systems) during these two decades. The largest single source for the missiles was the Soviet Union and its successor states, which exported 15,648 missiles, followed by France, which transferred 8,805 missiles. France also exported a large number of systems in a non-MANPADS configuration. Only in third place, do we find the United States with 5,479 exported missiles. We have to keep in mind, however, that the license-produced missiles of the European Stinger Program alone add up to 12,500 additional missiles. Other notable exporters during this period were the United Kingdom with 2,111, Sweden with 1,292, and China with 1,037 missiles.

On the recipient side, the most significant is India, which received 7,700 Russian missiles between 1990 and 2010. Other large recipients include South Korea (2,776), Venezuela (2,500), Greece (2,132), and Saudi Arabia (1,900). The following section will deal with a sample of transfers in greater detail, demonstrating the great variety of sales.

Azerbaijan

In the Nagorno-Karabakh War (1988–1994) the Armenian population of Nagorno-Karabakh fought for secession from territory claimed by Azerbaijan. Armenian and Azerbaijan troops clashed in several battles which demonstrated the material and military weakness of the Azerbaijanis. As a consequence, and notably since the financial windfall of oil production in the Caspian Sea, Azerbaijan has been persistently pursuing military superiority over Armenian and Nagorno-Karabakh forces. Advanced weapons have been sourced from the West, in addition to legacy Soviet weaponry abandoned or sold after the fall of the Soviet system.

In addition to short-range air defense (SHORAD) systems such as the Israeli SPYDER, which is truck-mounted, the Azerbaijani Army has also reported purchasing 18 Strela-3/SA-14 missiles and 10 launchers from Ukraine in 2007/08. This seems an unlikely number and type. Though the Strela-3 is a vastly improved version of the original Strela, and though it has a successful record, it was by no means a modern weapon by 2007, when it had been superseded by the SA-18 and SA-24. It is conceivable that the Azerbaijani's could not purchase Russian weapons due to Russia's support for Armenia. At the same time, there are some indications that Ukraine had also attempted to sell MANPADS to Armenia (Trend, 2012). The absence of reporting (and the report's claim that the Ukrainians wanted the export kept unpublished) shows that official reporting does not reflect a complete picture.

Bangladesh

While Bangladesh's security issues are largely internal rather than external, the Bangladeshi military has acquired MANPADS in three different transactions over the past two decades. In 1991/92, Bangladesh purchased 50 HN-5A missiles and an undisclosed number of gripstocks from China (SIPRI, 2012). This was supplemented in 2001 with a further shipment of 21 slightly upgraded HN-5JA1 versions of the missile. Between 2004 and 2007, the Bangladesh military procured a shipment of 250 advanced QW-2 missiles, presumably with an undisclosed number of gripstocks as well.

Brazil

Brazil has an arsenal of MANPADS for use by the three different armed services (army, air force, and navy). Between 1994 and 1997, the Brazilian Navy purchased 160 Mistral missiles from France for installation as point defense on its craft, including the aircraft carrier Minas Gerais. These are mounted in the SADRAL (6-cell) and SIMBAD (2 cell configuration). It is not clear whether the order also included individual gripstocks.

Given its vast territory, much of it in the Amazonian jungle, it is unsurprising that the Brazilians are investing heavily in point defense. This may be on the basis of lessons learned from observing the use of MANPADS during the Ecuadorian–Peruvian war.

North Korea

North Korea has a lengthy involvement with the use of rocket and missile artillery. The most recent known purchase of MANPADS was an extraordinarily large shipment of Igla type (either SA-16 Gimlet or the more advanced SA-18 Grouse) in 2001 (though this transfer does not appear in the UN Transfer Report). 3,000 missiles were apparently delivered, at what appears to be far below market rates. The single source reporting asserts that the missiles were bought at a cost of US $5,000 per missile with gripstock, and US $3,700 for each additional missile. Assuming once again the ratio of gripstocks to loads is about 1:4, the total transaction was around US $12 million: a negligible sum according to this single source (Isby, 2001). However, these prices are way below normal market prices for these missiles, indicating either the political nature of the transfer or a faulty source. A more realistic cost assessment (political considerations aside) would be US $120 million at US $40,000 per missile.

North Korea's first receipt of MANPADS consisted of a transfer of an unknown number of Strela-2 missiles and launchers from Egypt (Jane's, 2011b). These were reverse engineered for local manufacture. In the mid-1990s, North Korea received shipments of HN-5A from the China, and later of Strela-3 and Igla-1 from Russia. By then, Korea had managed to acquire a number of FIM-9A Stingers from an unknown source. All of these transferred missiles were later manufactured in North Korea under license (except the Stingers). Given the large purchase in 2001, it seems likely that there were problems in quality or quantity in manufacturing later acquisitions.

Transfers to North Korea of MANPADS represent a problem in two significant ways. North Korea has conducted pinpoint attacks on its rival, South Korea, using a variety of means as a way of making political points. The presence of large numbers of MANPADS, and the closeness of ROK's major airport to the border between the two states means that MANPADS could also be used in that role.

A second problem is the issue of proliferation. North Korea is on record as a point of origin for weapons transfers as well as dangerous technologies such as nuclear power and ballistic missiles to states that are otherwise limited in their access to such things. The state's need for scarce foreign exchange, its ideological stance and its isolation mean that it is possible that reverse-engineered MANPADS would be sold to customers without any checks or end-user agreements.

In summary, North Korea represents a black spot in attempts to control MANPADS. It is neither amenable to end-user controls, nor does it appear to adhere to export controls. North Korea does not report its small arms and light weapons (SALW) exports to the UN Register on Conventional Arms. Proliferation to NSAGs is possible.

Box 2: Libyan MANPADS and the Sahel

The Libyan case illustrates two major issues. First, the problem of identifying MANPADS flows in nations that do not report on MANPADS transactions. Second, the risk of regime dissolution to MANPADS stockpiles.

Many observers claim that the Libyan arsenal comprised some 20,000 MANPADS, with types ranging from Russian SA-7s through SA-24s (Chivers, 2011b). The authenticated transfers of which we have evidence are:

Table 9: Known transfers to Libya

Type	Origin	Number	Date	Source	Comments
SA-24/Grinch/ Igla-S	Russia	482	2006–2008	SIPRI, 2012	In Strelets vehicle-mounted configuration
Strela-2M/A	Bulgaria	Unknown	Unknown	Jane's, 2011e	
Strela-2/Grail/ SA-7	Russia	1500	1982	Jane's, 2011b	
Strela-2M/Grail/ SA-7b	Russia	1500	1982	Jane's, 2011d	
Igla-S	Russia	24	2004	Jane's, 2012m	In Strelets vehicle-mounted configuration
9K36 Strela-3/ Gremlin/SA-14	Russia	Unknown	2010	Jane's, 2012n	
TOTAL		**3506**			

Source: Adapted from Jane's 2011–2012 and from SIPRI, 2012.

3,500 missiles (without reference to gripstocks) were transferred to Libya before 2011. Chivers (2011b) who assessed shipments in one storage location in Libya saw shipping cases for Strela-2 variants from Bulgaria, Yugoslavia, and Russia. He estimated that the number stored at Ga'a base could have totaled 5,270 missiles and an unknown number of gripstocks. Ga'a base was the only one examined by Chivers, but other bases may also have contained similar numbers. There is no evidence, though it cannot be discounted, that the Libyan government managed to find additional sources for more advanced MANPADS. We would therefore estimate Libyan receipts at between 10,000 and 20,000 missiles.

Stockpile

All SA-7s are supposedly around 30 years old, which suggests that at least some of them will have exceeded their shelf-life. Unfortunately, there is very little information on the SA-14s in Libya, but articles about findings of SA-24 tubes are evident (Wedeman and Formanek, 2011; Malglaive, ND). So far it seems the SA-24 was stocked in Libya only in the Strelets version, a vehicle-mounted twin launcher, and not the MANPADS version (cf. Chivers, 2012)

Whatever security provisions had been in place before the Libyan uprising, these all disappeared with the uprising. There are several reports of unguarded stocks that were easily accessible (e.g. Bouckaert 2011). MANPADS storage boxes were photographed by foreign journalists (Chivers, 2011b) and in several cases, MANPADS were identified in the hands of Libyan insurgents (Chivers, 2011b). Some MANPADS appear to have been transferred across the borders (Stewart, 2012) possibly for transfer to Al-Qaida in the Maghreb (AQIM), to Hamas in Gaza, and possibly to Syrian insurgents. By mid-2011, the dispersal of an unknown but probably large portion of the Libyan MANPADS stockpile was a fact. Militias in Libya have been fighting over arms stockpiles as late as June 2012, when two groups fought over access to 22 containers of weaponry in Ad Dafniyah (Basar, 2012, p. 1). One problem here appears to be that the Libyan government, in its weak state, still depends on militia groups to carry out security relevant tasks such as border patrols. A resumption of state control will remain a challenge for Libya for quite some time (Basar, 2012, p. 2).

To add to the problem, the Gaddafi regime had hired hundreds, if not thousands of mercenaries from the Sahel region. After the fall of the regime and the death of Gaddafi, many returned to their home countries, often taking weapons with them. Many of these mercenaries were Tuaregs, with a strong grudge against the Malian government. There are suspicions that among the weapons they appropriated are an unknown quantity of MANPADS (Stewart, 2012).

Where have all the MANPADS gone?

Since the NATO intervention in Libya was limited to air-strikes, the weaponry outflow could not be prevented by the international community. Subsequently, it seems that some of the Gaddafi regime's MANPADS stock found its way to neighboring countries where it could contribute to a further destabilization of the Sahel. According to a UN report on the situation in Libya, an increase in arms trade in West Africa was noticed after the fall of the Gaddafi regime (UN, 2012. p. 10).

The beneficiaries of the lootings, apart from the dealers themselves, are probably primarily NSAGs in the region, such as the National Movement for the Liberation of Azawad (MNLA) in Mali, AQIM, especially in Algeria and Mali, and the Nigeria-based militant organization Boko Haram (UN, 2012).

The Tuareg fighters of the MNLA are supposedly in possession of SA-7s as well as SA-24s (Batacchi, 2012; Stewart, 2012). However, neither have been in evidence during the current civil war in Mali. The MNLA is aiming for the independence of the primarily Tuareg inhabited northern region of Mali, fighting with different intensity since as early as the 1960s (Batacchi, 2012). According to a Malian Army colonel, the "Tuareg rebels have [recently] used heavier, more sophisticated weapons and demonstrated improved military organization in their attacks" (Batacchi, 2012). MANPADS from Libya may have also reached the Somali al-Shabaab group (Batacchi, 2012) and Hamas in the Gaza strip (e.g. Harel and Issacharoff, 2011). There have been reports of Libyan MANPADS being found in Egypt (Ahram, 2011; Ma'an, 2012), but it is likely that Egypt is just a transit point for Gaza or Lebanon, and possibly Syria.

Discussion

A number of issues emerge from the Libyan case. There does not appear to be any clear enumeration of the Libyan MANPADS stockpile. Such records as may have existed have likely been destroyed. There is also some suspicion that the Gaddafi regime did not itself know the extent of its stockpiles. Most reports cite the number 20,000, but judging by available records of transfers, multiplied by a reasonable factor, the number is probably lower, though still over 10,000.

Libya also represents a situation in which regime dissolution endangers MANPADS stocks even had they been adequately protected. Basically, once a regime breaks down, Wassenaar or other agreements lose their validity (see Chapter 5). This is a sobering concept, since unstable state regimes are not rare, and many of those have MANPADS in their stocks.

There is also a methodological question. Reports—some from highly reliable sources, others not—suggest that Libyan MANPADS have reached as far south as Mali, west to Algeria, and north and east to Egypt, the Sinai, Gaza, Lebanon, and perhaps Syria. However, there is no hard public evidence (whatever clandestine sources exist). This means it is difficult to claim that the dispersal (or the numbers dispersed) is as reported, or less or more than that. Two telling items of evidence are missing: photographs or authenticated observations of the presence of these missiles is one. The other is valid evidence of use: so far, notwithstanding Israeli aerial attacks on Gaza, there is only one publicly authenticated report of a MANPADS shoot: an attack against a helicopter gunship in the Negev. One possible explanation is that there has been little evidence of compatible gripstocks being found with the missiles, resulting in difficulties to fire the MANPADS (see Chapter 2).

The effects of even a small number of MANPADS finding their way into Sahel countries could be an ongoing problem. Mali, for instance, has a handful of transport helicopters and two Hind (Mi-25) gunships, all of which would be highly vulnerable to MANPADS. And, as the example of the French civilian airliner shot down in Chad in 1978 shows, MANPADS would constitute a major threat to the region's civilian air traffic. However, no MANPADS have been fired at French jets or helicopters during the January 2013 offensive. This could mean a number of things: inability to operate the missiles, technical problems or a desire by the NSAGs to retain these weapons for an extended guerilla war.

Conclusion

Conclusions about the Libyan MANPADS stockpile are necessarily tentative. What can be said (and may need to be modified by further study) is:

- Libya had a stockpile of SA-7 and SA-14 MANPADS of around 10 to 20,000 missiles.
- The SA-24 systems were almost certainly in a self-propelled configuration, not MANPADS.
- While the numbers of MANPADS that were transferred at the end of the Gaddafi regime (by fleeing loyalists, arms buyers, or returning mercenaries) is probably not large, these weapons do constitute a game change in the Sahel. Neither Mali, Chad, nor Niger (the area most likely for the relocation of the weapons) have large or effective air forces. As a consequence, even a few MANPADS in the hands of dedicated and tactically minded rebels would pose an unacceptable hazard.
- If the Libyan MANPADS get transferred even further to Gaza, or to terrorists in Western countries, the dangers for civil aviation would rise significantly, due to the comparatively heavier traffic (see Chapter 1).

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Ecuador

Following the successful deployment of MANPADS by special forces during the Cenepa War (1995) against Peru, the Ecuadorians have added purchases of MANPADS.

Ecuador's initial purchase of MANPADS was a shipment of 240 Blowpipe missiles from the United Kingdom. Alongside an unknown number of SA-7 Strelas, these were used in the Cenepa war. It is uncertain to what effect, since different sources provide contradictory reports, but the Ecuadorians claimed success. The transfer of the Strelas has not been recorded publicly. For political, economic and military reasons, the Ecuadorians have since purchased only Russian and Russian-derived missiles. In 1994, the Ecuadorians purchased 72 HN-5A missiles from China, including 30 launchers (SIPRI, 2012). In 1998, 222 SA-16 Gimlets were purchased from Russia. 50 SA-18 Grouse were purchased from the same exporter in 2008/09 (Cooper, 2003; Herz, 2002).

The Ecuadorian purchases represent a case where a national military compensates for perceived weaknesses (the Peruvian air force was considered one of the more formidable in the Andes region at the time) in air assets by deploying ground-based anti-aircraft. In-and-of-itself this does not represent a negative trend and cannot be considered indicative of greater threat of proliferation. Ecuador claims to have a good record of SALW stockpile control, though this claim is unverified (Comando Conjunto De Las FF.AA., 2007)

Peru

The conclusion of the Cenepa War (1995) between Peru and Ecuador in which the Ecuadorians claimed a number of hits by MANPADS highlighted to the Peruvian military the importance of this weapon, notably against slow-moving attack aircraft and helicopters. As a consequence, Peru has been importing MANPADS at a rapid pace.

By 1996, the government of Peru had completed a deal with Bulgaria for the purchase of 417 Igla-1/SA-16 Gimlets, including 56 launchers (SIPRI, 2012; Karp, 2009). In 2009, two additional deals were made with the China National Precision Machinery Import and Export Corporation (CNPMIEC) for purchase of 15 FN-6 missiles for the Peruvian Navy (total value US $1.1 million), and an additional 18 QW-18 missiles for the Peruvian 1st special Forces Brigade (value US $1.4 million) (SIPRI, 2012).

As in the case of Ecuador (and perhaps some other South American countries) the Cenepa War triggered an awareness of the possibilities of MANPADS that had been less significant before. Given the limited aerial assets of the combatants, the use of light ground forces armed with MANPADS near and behind enemy lines in jungle terrain brought about an increase in requests for imports.

Syria

Due to its inferiority in fielding aircraft against its principle opponents (Israel and Turkey) and following Soviet/Russian doctrine, the Syrian military has consistently strengthened its anti-aircraft assets at all levels, including both heavy (SA-2, -3, -5), and medium (SA-8) AA missiles, and lighter MANPADS. Most of these were acquired from Russian block countries, with possible later imports from Iran.

Syrian MANPADS acquisitions (of Strela-2) started soon after the 1973 war with Israel. In 2003, Syria imported 300 Igla/SA-18 Grouse from Belarus. Given the needs of the Syrian military, it is reasonable to suppose that some older stocks of e.g. Strela-2 (SA-7) would have been transferred to clients down the line, e.g. NSAGs in Lebanon. In 2005/06 Russia transferred 200 SA-18s to Syria, albeit in the mounted form (SIPRI, 2012). Transfers may also have occurred from allies, specifically Iran, though these are not recorded in any of the open sources surveyed. One unsourced estimate puts Syrian imports at 30,000 units.

There is no evidence, for or against, that these imports were accompanied by a robust end-user agreement. Evidence from other purchases (e.g. Pantsyr-1 mobile anti-aircraft system) purchased by Syria is that samples were transferred to Iran. The same is possible in the case of the SA-18 purchases. The possibility of intentional transfers pales by comparison with the potential for stock dissolution under conditions of civil war, currently in process in Syria.

The total numbers of MANPADS in Syria’s arsenals is assessed by us and others at more than 8,000 items (Nerguizian and Cordesman, 2011, p. 4), including both ground and air force inventories. These are mainly obsolescent SA-7 with 100 SA-14 and some SA-18s. One source indicates that SA-16 are also present (UPI, 2003) without providing numbers or source. An estimate of the Syrian order of battle (OOB) supports this contention with the ground forces requiring slightly over 4,000 missiles and slightly over 1,000 gripstocks. The rest would be under air force control. For a more in-depth discussion of the situation brought about by the Syrian civil war, refer to the Box 3: “Syrian MANPADS in the Civil War”.

Box 3: Syrian MANPADS in the Civil War

Stockpile

Syria has been importing MANPADS since the first shipment in 1974. Since then, more modern, as well as older models have been acquired to an estimated over 8,000 items. In 2011, Russia agreed to supply Syria with Igla-S/SA-24 missiles in the mounted “Strelets” configuration. The recent shipment of self-propelled Strelets systems (which uses Igla-S missiles and containers) is claimed by Russian sources to be unusable in the MANPADS configuration. However, should a user acquire a compatible gripstock (which was *not* supplied by the Russians) it is conceivable that the Igla-S could be used in a MANPADS configuration.

The Syrian Army and Air Force have MANPADS in regular use. The Army assigns MANPADS down to fairly low levels, notably for protecting assets such as artillery battalions, which means the weapons are relatively easily accessible. MANPADS have been stored in the stockpiles of air-defense units as well: the Air Force is considered more loyal and steadfast to the regime than the land forces, which are composed largely of conscripts.

There have been reports that the Syrian government has transferred MANPADS to Hezbollah perhaps largely for the protection of the group's rocket assets notably those stored in the Bekaa Valley.

The Syrian civil war: An ongoing story

The Assad family, father and son, have been in power in Syria since 1975. Opposition to the regime has been fragmented and intermittent, and when it became threatening, was suppressed with great force. Public demonstrations in 2011, largely about domestic issues, led to reprisals and growing violence. As the opposition to Assad's rule became more violent in early 2012, demonstrations turned to armed confrontations. At the time, Syrian rebels in what has become a full-fledged civil war lacked major weapon systems. Examination of pictures and films shows use of a hodgepodge of weapons from shotguns and pistols to Austrian Steyr rifles, and even giant slingshots.

As the civil war accelerated, the Syrian Armed Forces became less discriminate in their use of weapons. Helicopters, both M-25 gunships and armed Mi-8 helicopter transports were used to rocket and bomb insurgent positions. Jet trainers

Table 8: Progress of MANPADS–use in Syrian conflict

No.	Event	Date	URL	Date accessed /downloaded
1	Syrian rebels claim military Mig 23 Fighter shot down (weapon unknown)	13 August 2012	http://www.youtube.com/watch?v=FX5qH4GvgQE&feature=related	12 September 2012
2	Syrian rebels down Fighter Jet in Idlib province	30 August 2012	http://www.youtube.com/watch?v=KcKXJJsqmW0&feature=related	12 September 2012
3	Complete SA-7 with gripstock shown	30 August 2012	http://www.youtube.com/watch?v=Eaaftfl8Qec&feature=player_detailpage	17 December 2012
4	FSA SA-7 shown	1 September 2012	http://www.youtube.com/watch?v=r8nObAcIWGE&feature=player_detailpage	26 November 2012
5	2 Videos: 1. SA-7 Two-man team apparently with complete system 2. Apparent attack and miss	14 October 2012 - Date on original YouTube videos (Blog piece dated 15 October)	http://atwar.blogs.nytimes.com/2012/10/15/heat-seeking-missiles-in-syria-the-sa-7-in-action-with-rebels/	2 November 2012
6	Picture of complete SA-24 System at Babla Base	13 November 2012	http://brown-moses.blogspot.co.uk/2012/11/new-type-of-shoulder-mounted-surface-to.html	17 December 2012
7	SA-24 without gripstock shown	15 November 2012	http://syrianarmyfree.com/vb/showthread.php?p=186692 http://brown-moses.blogspot.de/2012_11_01_archive.html http://newsmotion.org/tags/manpads	17 December 2012

8	Complete SA-24 Systems with grip-stocks in crates (possibly training)	16 November 2012	http://www.youtube.com/watch?feature=player_embedded&v=vuED7JCz3mU	17 December 2012
9	SA-16 in crates (comment in folder: 46 reg. outside Halab) [2 videos of the same event]	18 November 2012 (video released on 19 November)	http://www.youtube.com/watch?v=9EsJWLiONd8&feature=player_embedded http://www.youtube.com/watch?v=spiD0PASzzI&feature=player_embedded	17 December 2012
10	FSA Training on SA-7	20 November 2012	http://www.youtube.com/watch?feature=player_embedded&v=ItILHFTON6o	26 November 2012
11	Fired SA-7	ND	http://www.youtube.com/watch?feature=embedded&v=R0NEq0iTtzY (No longer available)	ND recorded
12	Mi-8 shoot down in Sheikh Suleiman	27 November 2012	http://www.youtube.com/watch?feature=player_detailpage&v=YaNvcJGRkf0	17 December 2012
13	SA-7 in Al-Tawhid	29 November 2012	http://cjchivers.com/post/37448078406/the-lions-of-al-tawhid-revisited-earlier-this	17 December 2012

(Aero L39 of Czech manufacture) have been filmed in the ground attack role, as have ancient Mig-21s and more modern Mig 24 ground attack craft. The rebel response has been to use 23, 14.5, and 12.7 machine guns mounted on 'technicals' to provide AA fire. Some Syrian air assets have been shot down by such means.

The progress of MANPADS–use by Syrian rebels
While the Syrian rebels had some successes using guns in the anti-aircraft role, shooting down helicopters and even fighter planes, the regime's Air Force essentially controlled the skies. By 31 July 2012, there were reports that outside interests (the original story from NBC did not give its sources) had supplied the Free Syrian Army (FSA) with unidentified MANPADS, which were variously reported as Stingers, though no supporting evidence emerged (*Reuters,* 31 July 2012). However, as the fighting progressed, films and photographs posted on the web began to show growing evidence of access to MANPADS all, apparently, from Syrian military stockpiles. The progression as we saw it moved from fighters flourishing empty MANPADS tubes, through tubes without, then with gripstocks, to full systems, actual use, and even training films by a rebel MANPADS professional.

Crucially, what Table 8 shows is the gradual progress over a period of eleven months from almost helplessness in the face of regime aerial attacks, to the destruction of warplanes. It delineates the importance of MANPADS as a weapon for small forces. Yet most significantly from this *brief's* perspective, the gradual penetration of MANPADS into the battlefield in Syria demonstrates, as perhaps no other case does, that ultimately MANPADS, however well secured, are at risk of dispersal from official hands, notably when a regime weakens.

Prognosis
For a period, the Syrian Army and Air Force seem to have successfully protected their MANPADS assets. There did not appear to be a wholesale leakage of these weapons into insurgent hands.

However, as time went by, and Syria's military proved less than capable of protecting its own assets, MANPADS, including more advanced Igla-1 and Igla-S have fallen in some quantity into rebel hands, notably when Syrian Army bases have been overrun and weapon stockpiles captured. Insofar as can be seen from visual evidence on the web, Igla-S have not been shown in action, but Strela 2 and Igla-1 appear to be full systems, and one of those seems to have been used successfully. It can be assumed that over the next few months, if hostilities continue, the rebels will learn how to use the MANPADS, and the numbers of shoot-downs of regime aircraft will increase.

The ransacking of regime armories was a feature of the rebellion in Libya. In Syria, as in Libya, an important issue from this *brief's* perspective has to do with the effects of the political results of the war on the MANPADS picture. Several different scenarios have been posited for the outcome of the civil war in Syria. Roughly, they can be divided into government victory and retention of Assad and Ba'ath power; rebel victory and regime change; and a stalemate in which the Assad and Alawite monopoly of force is broken, no clear winner emerges, and internal forces—Kurds, Sunnis, Salafis, Alawites, Druze—control different cantons of the country.

Should the Assad regime maintain its power, it is likely that they will need to engage in a serious program of collecting the missing MANPADS, which otherwise will remain a threat to local civilian and military aircraft. An outright rebel victory would present the same problem, which, given the fractured nature of the Syrian opposition, would be no easy task, and a "Libyan" result (a formal government supported, and sometimes opposed, by armed militias) could well emerge. Finally, there is the problem of cantonization (cf. Karon, 2012). If Syrian MANPADS stockpiles *are* randomly ransacked by opposition NSAGs who have their own interests to protect, the danger that Syria's MANPADS stockpile (which before the conflict stood at over 8,000) would disperse to numerous NSAGs in these cantons is great. In this case, Kurdish groups such as the PKK as well as home-grown Syrian Kurds, Palestinians, Alawite and Sunni provincial powers, and NSAGs in Lebanon could acquire these weapons, whether as tradeable resources, for their own use in self-defense, or for attacking civilian targets in acts of terrorism. Given the relatively better stockpile conditions in Syria (compared to Libya), as well as the better organization and military skills of local and neighboring NSAGs, it is likely that such a scenario would constitute a serious threat, as 'excess' MANPADS, and cooperation between such groups cause percolation of the weapons throughout the Middle East.

Lebanon is already fractured badly. It is likely that MANPADS would fall not only into the hands of Hezbollah, a Shi'ite organization, but also into the hands of opponents in the Christian, Sunni, and Druze camps. Lacking the support of Syria, Hezbollah could be tempted to arm itself against attacks by internal and external foes (e.g. Israel) and increase its arsenal. Notably, they would be interested in better protection for their rocket assets, which to date are exposed to Israeli air attacks.

A massive transfer of MANPADS to the hands of NSAGs may well trigger preemptive strikes by regional powers (e.g. Turkey against potential Kurdish zones, and Israel against Hezbollah shipments) with serious local consequences.

Conclusion

At the time of writing, the Syrian saga was in the making. Both rebels and the regime in Syria are still fighting. Still, some tentative conclusions can be made:

- The increased use of air assets by the Syrian Armed Forces is likely to mean that the FSA (and their supporters) will be highly motivated to acquire MANPADS to defend the revolution and civilian population under their control.
- We are beginning to see the use of MANPADS as a form of successful defense against aerial attack: at least one shootdown, and increasing use of flares by Syrian attack craft.
- The government has not succeeded in its efforts to ensure that MANPADS (along with other significant weapons) do not fall into rebel hands.
- What appears to be successful (though evidence is inconclusive) is the separation of gripstocks from MANPADS rounds, which may have been one cause for the limited use of MANPADS so far, and their slow introduction into the battlefield.

- A radical change in the situation in favor of the rebels will expose the MANPADS stockpile to volatile changes, and possibly to untraceable dispersal throughout the Levant. This would have unforeseen consequences regarding the balance with Israel, with Turkey, and possibly within Lebanon.

Venezuela

The purchase of MANPADS by Venezuela should not be seen in isolation. The Venezuelan armed forces are in the process of building a multi-layered air defense system to compensate for their weakness in aircraft. Negotiations and some purchases have been made for high-altitude, medium-altitude, and low-altitude missile batteries. The purchase of MANPADS to protect the major surface-to-air missile (SAM) assets is part of this process. Venezuelan moral, and clandestine military and economic support to the Revolutionary Armed Forces of Colombia (FARC) rebels in neighboring Colombia, have escalated tensions between the two Latin American neighbors. Strong support from the United States for Colombia has meant that the balance of air power is largely in Colombia's favor. As a result, Venezuela has recently (2010–11) invested heavily in the acquisition of anti-aircraft assets, including one of the largest MANPADS shipments in history.

Transfers to Venezuela have included three sources. The Venezuelan Army acquired a limited number of RBS-70 missiles and systems from Sweden. The systems included four Giraffe radars, each of which can handle six firing posts, so it is conceivable that the total delivery of missiles was around 50 units at most, sufficient to equip one air defense group. Some of the missiles were replaced in 1999 by a limited order for the Mark II missile. A number of Mistral missiles, in the ATLAS configuration, were supplied by France at the same time (Jane's, 2011g). These are vehicle mounted rather than MANPADS systems. Venezuela then acquired an unknown number of 9K38, Igla/SA-18 'Grouse' systems from Russia (Jane's 2012c).

In 2009, Venezuela received a shipment of 2,400 missiles from the Russian company KBM. Many of these, perhaps all, are SA-24 Grinch (Igla-S), the newest MANPADS in the Russian arsenal, comparable to the latest US Stinger. While the UN Register of Arms records only 1,800 delivered, and does not specify type (UNODA, 2012), other sources indicate the much higher number (McMichael, 2010). Several films have since appeared (Arcesolo, 2009; Venezueladefensa, 2011) showing the missiles and their launchers on parade, and claiming the existence of a full brigade's worth of the weapons (Arcesolo, 2009). If the Venezuelans follow Russian doctrine, that will mean at least 214 operative launchers with three reloads each, or possibly double the amount of launchers with fewer reloads.

Another film shows MANPADS storage (Venezuela-defensa, 2011) which on the face of it indicates that these weapons are properly securitized and safe (though for a contrary view see Clinton, 2009a). Venezuela has not recorded any losses of the weapons. Even though the Venezuelan government has actively supported FARC rebels, supplying ammunition, funds, and occasional weapons, it seems unlikely that they would go so far as to officially transfer these newest weapons to FARC, at least in the short term. Concern has been expressed by US sources that corruption in the Venezuelan military is likely to facilitate the transfer of MANPADS to FARC, which is on record as demanding these weapons from its allies (Clinton 2009a and see the Peruvian case). Large transfers, however, are always dubious and should be examined with care. In this case, it appears that the Venezuelan demand comes about as a result of Colombia's (their main potential opponent) superiority

Box 4: The Mombasa attacks and the Yemeni arms market

In 2010, an Israeli Arkia passenger airliner took off from Mombasa airport to Tel Aviv. Two Strela/SA-7 MANPADS were fired at the airliner as it took off. Both missiles missed. The airliner continued on its way and landed safely in Tel Aviv.

Of interest to us here is the path the missiles took to Kenya. Both missiles were part of a shipment sold by Ukraine to Yemen in a normal government-to-government transaction, which included an end-user certificate. While in Yemeni official stockpiles, the missiles were diverted (by theft or through an inside job) and disappeared from the inventory. They were apparently identified in one of Yemen's many weapons markets and were purchased by an arms trader who shipped them to Mogadishu, where they were offered openly for sale. From Somalia, they were smuggled into Kenya, where they were used in the attack.

Partly as result of the attack, the United States and the Yemeni authorities engaged in a program to sop up available MANPADS that were being offered for sale in Yemen's (semi-legal) weapons markets. A report by the US State Department concluded that most of the freely available MANPADS had been bought and then destroyed. Remaining stocks in private hands were in the hands of tribal leaders or Islamic groups who would not give up these weapons under any circumstances (Krajefsky, 2004; Seche, 2009)

Summary
This brief anecdote illustrates a number of issues:

- Unless accompanied by physical on-site inspection, end-user certificates are not robust enough to stop diversion, particularly of single items such as MANPADS.
- The missiles in questions were transported at least twice across national borders. In the absence of robust border controls, MANPADS are relatively easily moved about through porous borders.
- Notwithstanding many predictions (e.g. ICAO, 2007) the hit on the Arkia airline does not appear to have had a major impact on the airline business. While an Arkia spokesperson declined to provide relevant information, there is no evidence of any sharp, continuous drop in passenger flights to Mombasa or similar destinations. However, tourist revenue in Kenya dropped sharply for a brief period before rising again.
- On-ground security, and particularly intelligence, could have contributed to stopping the transfer of MANPADS across borders, and the actual attack.
- Any system to stop illicit MANPADS transfers must involve all the potential links in the chain. In this case, reining in the free trade in MANPADS in Yemeni markets probably contributed to greater security. Certainly the free availability of MANPADS in Yemen's freewheeling weapons emporia was a causal factor assisting in the Mombasa attack.

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in air assets and training. This does mean, however, that as the Venezuelans' air force reach parity with Colombia's we may see a growing risk of transfer of MANPADS, notably of the older versions, even if the Venezuelan system is not as riddled with corruption as the United States suggests. The Venezuelan case highlights the point that a regime that may be seen as reliable and well-disposed towards an exporter (in this case Sweden and France) at one point, can easily switch fronts in the long or even mid-term.

Originator picture

In this section, we approach the transfer picture from the perspective of the suppliers and countries of origin. Very few originators have been completely transparent about their sales or transfers. Some of the manufacturing states such as Bulgaria and Romania, which had been Soviet dependencies in the past, no longer manufacture or export MANPADS. Others such as the Ukraine are destroying or selling off Soviet-era surpluses. The China, Russia, Sweden, and France are still the major source countries for MANPADS.

Bulgaria

Bulgaria's manufacture of MANPADS was part of its strong relationship with the Soviet Union. Both cooperation and manufacture of MANPADS by the Bulgarian manufacturer Vazovski Machinostroitelni Zavodi (VZM) ceased with the breakup of the Soviet Union. However, until the breakup, three MANPADS types were manufactured in Bulgaria and transferred abroad:

Strela-2M: Manufactured under license by VZM (Jane's, 2011d), an undisclosed number of these MANPADS may have been transferred to Libya, since some old storage boxes (similar to the Russian ones, since the missile is identical) were found in Libya after the revolution (Chivers, 2011b). There is no evidence of numbers or condition.

Strela-3: VZM produced the Strela-3/9M36 (the 9M36-1 is the export variant)/SA-14 Gremlin under license (Jane's, 2012n). Insofar as is known, none were transferred or exported from Bulgaria in any form.

Igla-1E: The Igla -E was a license-produced version of the Igla (SA-16 Gimlet) produced by VZM in Bulgaria. It was sold to a number of states and possibly to one NSAG (Hamas in Gaza). Production was limited and VZM ceased production of all MANPADS about a decade ago, though missiles are still sold from Bulgarian Army stocks (Jane's, 2012t).

Table 10: Igla-1E transfers

Recipient	Number	Date	Comments
Afghanistan	?	?	
Ecuador	20	?	
Gaza & West Bank	?	2005	Rumored
Hungary	?	1999	
South Korea	?	?	
Peru	56 launchers	1994	
Peru	190 missiles	1994	
Peru	21	1995	"Systems", so presumably gripstocks with missiles.

Source: Adapted from Jane's, 2012t. Peruvian transfer detailed in UN Arms Register.

Summary: Bulgarian MANPADS transfers

Bulgaria was never a major player in the MANPADS transfer world. However, during the period of close relationship with the Soviet Union, it may have served as a conduit for transfer where the Soviet Union did not wish to appear as principal, or for its own reasons. As a Soviet satellite, it also manufactured and sold its own versions of Soviet originals, an activity that was wound down with the state's shift to a Western orientation. There is evidence for transfers to Libya of early Strela-2 MANPADS, possibly via Libya to the Hamas in Gaza (Chivers, 2011b). The transfer to Peru is the single largest Bulgarian transfer, as Peru developed a short-term romance with the Soviet bloc.

China[16]

China's first MANPADS were licensed and unlicensed copies of Russian originals. However, China has been developing two parallel series of MANPADS, many of which are offered for export. Early variants were copies of weapons from Russia and the United States. Later variants are based on indigenous technologies. Like the Soviet Union before it, China has exported systems as well as licensing production to allies. Its newest systems are as yet unavailable abroad, but if China follows its previous pattern, the newer MANPADS models will also become available on the market.

HN-5A/B: The HN-5 is an improved version of the Russian Strela-2. It was accepted into PLA (People's Liberation Army) service in about 1991. The technology was transferred to Pakistan for indigenous development of the Anza Mk I MANPADS.

Table 11: HN-5A/B transfers

Recipient	Number	Year
Afghanistan	400	1982
Albania	100	1978
Bangladesh	2,050	1991–92
Bolivia	28	1985
Cambodia	1,000	1982
Iran	500	1986–88
Myanmar	200	1990–92
North Korea	600	1983–94
Pakistan	1,100	1987–98
Thailand	1,150	1987–88
TOTAL	**7,128**	

Source: Adapted from Jane's (2011i).

As can be seen from Table 11, customers for the HN-5 series include clients, allies, and others such as Thailand with no particular attachment to the Chinese sphere. In addition to systems, China exported knowledge openly to Pakistan, and perhaps clandestinely to Iran to counterbalance the US interest in those countries.

QW-(1,2,3,4,11,18): The original QW-1 is a second-generation MANPADS and may be partly based on the FM92 Stinger. It is similar to the original Stinger in its performance and many attributes. 1,350 were transferred to Pakistan in 2008 and the Anza Mk II is based on this MANPADS (Janes, 2012b). Some units may have been transferred to Hezbollah in Lebanon as technical samples (Janes, 2012b), though there is no concrete evidence for that.

The QW-2 is a further development of the QW-1 and similar in performance to the Igla series (Janes, 2012o). In addition to the PLA, Bangladesh received a shipment of 250 missiles in 2007.

[16] In this *brief*, China is used to refer to the territory excluding Taiwan.

The QW-3 is a low and ultra-low targeting variant of the QW series. In addition to passive IR, it may also use a laser-guided mode. The QW-3 is in service with the PLA, and has been transferred to Indonesia, which acquired 210 units between 2006 and 2008.

The QW-4 has entered PLA service and insofar as is known has not been transferred to any other user than the PLA. QW-11 and 18 are in development, and examples have been shown at Chinese trade fairs. Insofar as is known, no transfers have occurred for these models.

Table 12: QW transfers

Recipient	Number	Year	Notes
Bangladesh	250	2007	
Hezbollah?	?	?	Unverified
Indonesia	210	2006-08	
Pakistan	1,250	2008	
TOTAL	**1,710+**		

Source: Adapted from Jane's, 2012a, b, o, p, q, r.

FN-6: The FN-6 is an all-aspects MANPADS intended for use against cruise missiles and other low-flying targets. Apart from the basic MANPADS version, there are a number of variations. It is not clear whether the FN-6 version exported was the MANPADS version or its self-propelled multi-missiles mount variant.

Table 13: FN-6 transfers

Recipient	Number	Year
Cambodia	?	2009
Malaysia	16	2010
Pakistan	?	2010
Peru	25	2009
Sudan	10	2010
TOTAL	**51+**	

Source: Adapted from Jane's, 2011f

A more advanced version of the FN-6 labeled FN-16 (designated HY-6 within the PLA) has been reported to be in service with the PLA. There is unconfirmed information that systems have been transferred to Malaysia, Cambodia, Sudan and Peru.

Conclusions: Chinese MANPADS transfers

The total number of MANPADS transferred by China is not high when compared to the United States and Russia. China may have transferred around 10,000 MANPADS in all. What is more worrisome is the willingness of China to transfer technology to regimes that are known to have no reluctance to transfer missiles to NSAGs, as well as to transfer technical samples directly to NSAGs.

Egypt

The Strela-2 was used by the Egyptians successfully during the Yom Kippur war, and after the war the 'Ayn-al-Sakr' MANPADS was produced indigenously by reverse engineering the Strela-2. The missile has been in service with the Egyptian Army since 1985. Small numbers were exported to Kuwait (36 systems in 1987) and Oman (unknown number, unknown date. Jane's, 2011h). It is also possible that small numbers have been transferred clandestinely to Hamas and the Palestine Liberation Organization (PLO) in Gaza and/or the West Bank.

Egypt also transferred an unknown number of Strela-2 to North Korea and Pakistan as technical samples to stimulate their indigenous MANPADS development programs. Officially, at least, the Soviets had no knowledge of these transfers.

France

The French indigenously developed Mistral and Mistral II MANPADS are one of the more successful export MANPADS and have been exported to 23 countries (Janes, 2011g).

Mistral: The Mistral is a tripod mounted weapon which makes it less flexible and probably less attractive to NSAGs. On the other hand, its robust construction and very reliable dual-channel IR seeker provide a robust military battlefield solution. Entering service in 1990, the Mistral, in addition to the French military, was transferred to several other countries (see Table 14).

Table 14: Mistral 1 transfers

Recipient	Number	Year	Notes
Austria	500	?	
Belgium	714	1995	+118 launchers
Brazil	290	1994	ATLAS
	320	1997	
	160	1997	SIMBAD[17]
Brunei	88	1999/2006	

[17] A naval multi-launcher version of Mistral.

Chile	750	1997	
Colombia	?	?	
Cyprus	290	2005	
Ecuador	100	1998	
Estonia	?	2009	
Finland	540	1989	
Gabon	60	1988	
Hungary	180	1999	
India	20	?	
Indonesia	?	2006	
Italy	?	?	
Jordan	?	?	
Kenya	100	1992	ALBI
Malaysia	?	?	
New Zealand	39	1998	
Norway	400	1997	
Oman	230	?	
Pakistan	50+	2010	ALBI
Qatar	500	1996	
Romania	?	?	
Saudi Arabia	1	2009	
Singapore	500	1996	
South Korea	?	?	
Spain	200	2008	
Taiwan	?	?	
Thailand	36	1997	
UAE	524	1994	
Venezuela	?	?	ATLAS
TOTAL	**7,591+**		

Source: Adapted from Jane's, 2011g.

It should be noted that the Mistral has a number of versions. The ATLAS and ALBI versions are self-propelled rather than man portable air defense systems. These systems consist of multi-missile launchers and target-acquisition systems mounted on a vehicle. A naval multi-launcher version called SIMBAD has also been exported to a number of nations.

Mistral 2: The Mistral 2 entered service in 2000, and production of the original Mistral ceased at that time. In the economic climate during the following decade, Matra BAe Dynamics Alenia Marconi Systems (MBDA), who now owned the Mistral production line, sought co-production with manufacturers in new markets, heavily emphasizing the self-propelled and mounted versions of the Mistral 2. The Mistral 2 has been sold to four countries, often in the mounted version (ATLAS or ALBI).

Table 15: Mistral 2 transfers

Recipient	Number	Year	Notes
Estonia	100	2008	
Indonesia	?	2006	ATLAS on local vehicle
Saudi Arabia	200	2008	
UAE	?	?	
TOTAL	**300+**		

Source: Adapted from Jane's, 2012s.

Summary and conclusions: French MANPADS transfers

Overall, France, one of the countries that is not only a signatory of the Wassenaar Arrangement but also lives up to its responsibilities that come with it, is conservative and careful with its missile exports. Questions however remain, as for instance, with the transfer to Venezuela, which is suspect of complicity in transfer to FARC NSAG.

It should also be noted that, while France has never made any official technical transfer to other states of MANPADS technology, at least two missile systems are partially based on the Mistral: the guidance system for the Korean Singung and the Chinese FN-6 MANPADS may have benefited from reverse engineering the Mistral.

Germany

Germany's first production of a modern MANPADS has been the joint production (with Greece, the Netherlands, and Turkey) of a version of the US FIM92 Stinger intended for their own use but made available to NATO as well. This weapon is not available for export outside NATO. However, while not recorded as a transfer, West Germany apparently received a number of Redeye MANPADS from the United States. In 1993/94, 300 of these were transferred to Turkey as part of an aid package (Sipri, 2012). This has been the largest transfer from Germany recorded publicly. A few individual units of RBS-70 were also transferred to Finland by agreement with Sweden, perhaps as samples for evaluation. With that one exception, Germany has not been a major exporter of MANPADS.

Iran

Iran's first home-manufactured MANPADS were copies of Russian and Chinese technologies provided by sympathetic countries such as the China. On those bases, Iran, which has a self-reliance ideology in weapons production, has developed its own MANPADS versions. The Misagh-1 was based largely on 2nd generation QW-1. The weapon is no longer in production. Aside from the Iranians, reports claim that the weapons have probably been supplied to Hezbollah in Lebanon, and to Iraqi insurgent groups. The Misagh-2 is based upon the Chinese QW-2 and similar in performance and components to the early Igla series.

Iran has been deeply implicated in the transfer of MANPADS to NSAGS, notably to Hezbollah in Lebanon (Schroeder, 2012) and to Shi'a insurgents in Iraq (Rice, 2008). Some of the transfers have been of Chinese weapons (Rice, 2008), which indicates that Iran does not adhere to its end-user commitments, or that they were supplied without one.

North Korea

In 1978 or thereabouts, North Korea started fielding a domestically produced copy of the Strela-2 supplied for the purpose by Egypt. The missile termed Hwasung Chong was used operationally to shoot down a misguided US helicopter that had crossed the demilitarized zone (DMZ) (Burdick, 2010, p. 270). The cloning of the Strela-2 was followed by licensed production of Strela-3 (SA-14) and later of Igla-1 (SA-16). Reverse engineering was carried out on Stingers that reached North Korea, and locally manufactured variants are in use with the North Korean Army (see Stimmekoreas, 2012). It has been suggested that clones of the SA-14 and SA-16 have been exported to Cuba, though little is known of this transfer (Janes's, 2012u).

Poland

Poland produces two indigenous MANPADS, Grom-1, heavily based on the Russian Igla-1/SA-16 Gimlet, and Grom-2 which is a native Polish development. The Grom has been exported to the following two countries:

Conclusion: Polish MANPADS transfers

The Polish case illustrates two issues that should always be kept in mind. First, any moderately industrialized state would be able to retroactively engineer a MANPADS once it has had time to analyze one. Second, transfers to other nations almost always involve the risk of these weapons falling into other hands. In the Grom case, poor security and high corruption within Georgia, on the one hand, and either battlefield losses or defecting soldiers on the other have brought MANPADS into the possession of irredentist NSAGs.

Soviet Union (to 1991)/ Russia (1991 onwards)

Soon after the emergence of the Redeye in the United States, the Soviets developed the 9K32 Strela-2/SA-7 Grail, which entered service in 1968. Like the Redeye, this was a first generation MANPADS. Soviet MANPADS have since been constantly upgraded, with a new family, the 'Igla' series emerging in 1981. All of these versions have been made available to export, and many have been used successfully in combat. Some Russian MANPADS missile exports are in mounted form, such as the Strelets configuration of missile tubes mounted on an armored carrier. The Russians argue that this form of self-propelled air defense system (SPADS) mounted on a vehicle is qualitatively different from the MANPADS configuration of the same system, and that SPADS cannot be converted to MANPADS form. A couple of experts interviewed for this *brief*, as well as our own analysis suggest that this is not the case. If an appropriate gripstock is available, a missile intended for a Strelets system can be used as a MANPADS.

Table 16: Grom transfers

Recipient	Number	Date	Comments
Georgia	100	2007/ 2008	Two Grom MANPADS were found by Russian forces in Chechnya, identified by part number and writing as part of the Georgian shipment. A further two were captured by Ossetian forces during the Georgian–Russian conflict
Indonesia	2 systems	2010	Both systems mounted on Zubr attack craft, so most likely not in the MANPADS configuration.

9K32 Strela-2/SA-7a/b Grail: The Strela-2 was exported in huge numbers to Soviet allies and clients during the Cold War and the period of independence and liberation wars in the second half of the twentieth century. Table 17 summarizes those transfers. In addition, the weapons were transferred to other clients for whom no numbers or dates are available, so the total in the table is well below actual transfer numbers.

Table 17: Strela 2 transfers

Recipient	Number	Date	Comments
Afghanistan	Unknown	1972	
Algeria	1,000	1975/1976	
Angola	1,000	1981	
Argentina	Unknown	1987/88	Destroyed under deal with United States
Armenia	Unknown	Unknown	
Azerbaijan	Unknown	Unknown	Served as basis for local version
Belarus	Unknown	Unknown	
Benin	Unknown	Unknown	
Botswana	60	1988	
Bulgaria	Unknown	Unknown	
Burkina Faso	Unknown		
Cambodia	233		
Cape Verde	Unknown		
Chad	8		
China	Unknown		
Croatia	500		
Cuba	100		
Cyprus	50		
Czech Republic	Unknown		
DR Congo	10		
Egypt	10,000		
El Salvador	Unknown		
Eritrea	Unknown		
Ethiopia	1,550		
Finland	200		
Gaza and West Bank	Unknown		
Georgia	Unknown		
Germany (GDR)	Unknown		
Ghana	Unknown		
Guinea	Unknown		
Guinea-Bissau	5	Unknown	
Guyana	Unknown		
Hungary	Unknown		
India	500		
Iran	Unknown		
Iraq	Unknown		
Jordan	300		Destroyed by NAMSA & US
Kazakhstan	250		Some destroyed by NAMSA & US
Kuwait	Unknown		
Kyrgyzstan	Unknown		
Laos	100	1984	
Lebanon	250	Unknown	
Libya	1,500	1978–1982	
Mali	40	Unknown	
Mauritania	100	Unknown	
Mauritius	Unknown	Unknown	
Moldova	Unknown	Unknown	
Mongolia	Unknown	Unknown	
Montenegro	Unknown	Unknown	
Morocco	200	1981	
Mozambique	Unknown	Unknown	
Namibia	Unknown	Unknown	
Nicaragua	1,151	1982–85	
Nigeria	Unknown	Unknown	
North Korea	250	Unknown	
Oman	Unknown		
Peru	500	1978–81	
Poland	1,000	1970–72	
Qatar	Unknown	Unknown	
Romania	Unknown	Unknown	

Recipient	Number	Date	Comments
Serbia	Unknown	Unknown	
Seychelles	50	1979–80	
Sierra Leone	Unknown	Unknown	
Slovenia	Unknown	Unknown	
Slovakia	120	Unknown	
South Africa	Unknown	Unknown	
Sudan	70	1981–84	
Syria	15,000	1970–83	
Tajikistan	Unknown	Unknown	
Tanzania	200	1977–78	
Tunisia	Unknown	Unknown	
Turkmeni-stan	Unknown	Unknown	
Uganda	200	1975/87	
Ukraine	Unknown	Unknown	
Uzbekistan	Unknown	Unknown	
Vietnam	5,080	1971/75/96/99	
Yemen	80	1989/91	
Zambia	100	1979	
Zimbabwe	Unknown	Unknown	
TOTAL	**41,507+**		

Source: Adapted from Jane's, 2011b.

Two shipments stand out in terms of volume: Syria, which received 15,000, and Egypt, which received 10,000 Strela-2. Both countries were engaged in active or semi-active wars with Israel at the time of transfer. Vietnam, Nicaragua, and Angola also received large transfers and were engaged in wars at the time. Jane's includes a number of Strela-2 transferred to Gaza and the West Bank, though it seems unlikely that these shipments were directly from Russia. More likely these were transferred from Egyptian and/or possibly Jordanian stocks. In addition, Egypt transferred individual weapons to North Korea and Pakistan to promote their manufacture of MANPADS.

To summarize, huge amounts of Strela-2 were transfered, in many cases apparently without end-user assurances. Considering the political climate at the time—almost the height of the Cold War—we can safely say that the manufacturing country saw these weapons as a diplomatic tool.

9M36 *Strela-3/SA-14 Gremlin:* The Strela-3 was designed to compensate for the weaknesses of the Strela-2a/b. With almost the same range, altitude and weight, it was characterized by a second-generation seeker system, and a more powerful warhead.

Table 18: Strela-3 transfers

Recipient	Number	Date
Afghanistan	Unknown	Unknown
Angola	Unknown	Unknown
Armenia	Unknown	Unknown
Azerbaijan	Unknown	Unknown
Belarus	Unknown	Unknown
Bosnia-Herze-govina	Unknown	Unknown
Bulgaria	200	Unknown
Croatia	500	Unknown
Cuba	Unknown	1966/67
Czech Republic	200	1984
El Salvador	Unknown	Unknown
Finland	105	1986/87
Gaza and West Bank	Unknown	Unknown
Georgia	Unknown	Unknown
Germany (GDR)	Unknown	Unknown
Hungary	300	1987/89
India	600	1995/97
Iran	Unknown	Unknown
Jordan	200	1987
Kazakhstan	50	Unknown
Kosovo	Unknown	1999
Kuwait	500	1985
Kyrgyzstan	Unknown	Unknown
Lebanon	Unknown	Unknown
Libya	Unknown	<2010
Moldova	Unknown	Unknown
Nicaragua	117	1986/87/91
North Korea	Unknown	Unknown
Peru	Unknown	Unknown
Poland	100	1987
Serbia	45	Unknown
Slovakia	Unknown	Unknown
South Africa	Unknown	Unknown
Sri Lanka	Unknown	Unknown
Syria	1,500	1987/89
Tajikistan	Unknown	Unknown

Turkmenistan	Unknown	Unknown
Ukraine	Unknown	Unknown
United Arab Emirates	100	1986/87
Uzbekistan	Unknown	Unknown
Vietnam	Unknown	Unknown
TOTAL	**4,517+**	

Source: Adapted from Jane's, 2012n.

The largest recipient for this model was again Syria, though as can be seen, the total volume of Strela-3s shipped is much lower than that of the Strela-2. This may be because of general easing of tensions in the post-Cold War era, or because information about the Igla series was becoming known, and customers were waiting for the new weapon. Beyond supplies to traditional allies and clients, Strela-3s were supplied to very few Western oriented states, such as Jordan.

9K310 Igla-1/SA-16 Gimlet: The Igla-1 was the first of the Igla series to supplant the Strela. It is characterized by greater range and a third-generation IR seeker.

Table 19: Igla-1 Transfers

Recipient	Number	Date	Comment
Afghanistan	100	1999/2000	
Angola	150	1990	
Azerbaijan	Unknown	Unknown	
Belarus	Unknown	Unknown	
Bosnia-Herzegovina	Unknown	Unknown	
Botswana	50	1996	
Brazil	Unknown	Unknown	
Bulgaria	Unknown	Unknown	
Croatia	Unknown	Unknown	
Cuba	100	1989/90	
Czech Republic	Unknown	Unknown	
Ecuador	242	1998	
Finland	90	1986	
Gaza and the West Bank	Unknown	2005	
Georgia	Unknown	Unknown	
Germany (GDR)	Unknown	Unknown	
Hungary	Unknown	1999	
India	2,500	1990/91	
Indonesia	16	2003	
Jordan	240	Unknown	
Kazakhstan	Unknown	Unknown	
Kyrgyzstan	Unknown	Unknown	
Laos	50	1999	
Lebanon	Unknown	Unknown	
Macedonia	Unknown	Unknown	
Moldova	Unknown	Unknown	
Myanmar	100	1999	
Nicaragua	360	1987/88	
North Korea	1250	Unknown	
Peru	838	1992–96	
Rwanda	Unknown	<1994	
Saudi Arabia	Unknown	Unknown	
Serbia	226	1995	
Slovakia	Unknown	Unknown	
Slovenia	4	2003	
Somalia	Unknown	Unknown	
South Korea	Unknown	Unknown	
Sri Lanka	Unknown	2006	
Tajikistan	Unknown	Unknown	
Turkmenistan	Unknown	Unknown	
Ukraine	200	Unknown	
United Arab Emirates	400	1998/99	
United Kingdom	31	2005/06	
United States	313	2006/07	Supplied under counter-measure agreement?
Uzbekistan	Unknown	Unknown	
Vietnam	100	1996/97	
TOTAL	**7,360+**		

Source: Adapted from Jane's, 2012f.

The emergence of the Igla-1 in 1981 also marked a change in the Soviet Union's export strategy. Egypt and Syria, the two major overseas clients for the Strela did not purchase any of the early Igla systems—Egypt because it was now concentrating on Western weaponry, Syria, presumably because it could not afford new weapons for economic reasons. The largest purchaser was India, possibly because the aging Indian Air Force was considered insufficient for defense against the Pakistani Air Force, which was being supplied by the United States. The United States also acquired some Iglas under an agreement with the Russians for mutual development of counter-measures (the "U.S.-Russia agreement on MANPADS cooperation" See Embassy Moscow, 2004).

9K38 Igla /SA-18 Grouse: In terms of transfers, the Igla marked a singular change in Russian export strategy: for the first time, most recipients were not former Soviet allies or clients.

Table 20: Igla transfers

Recipient	Number	Date	Comment
Armenia	200	1995/96	
Belarus	Unknown	Unknown	
Brazil	168	1994	
Colombia (FARC)	Unknown	Unknown	Via either Venezuela or theft from Peru
Czech Republic	Unknown	2010	
Ecuador	50	2001	
Egypt	600	2007	
Eritrea	259	1995/99	Some transferred to UIC Somalia
Finland	100	1990	
Gaza and West Bank	Unknown	2005	
Germany	Unknown	Unknown	
Hungary	Unknown	Unknown	
India	2,500	2001/03	
Iran	Unknown	Unknown	
Jordan	1,900	2001/09/10	Replace-ment for Strela-2
Laos	50	2005	
Malaysia	40	2002	
Mexico	Unknown	Unknown	
Myanmar	20	Unknown	Number in service, no import number
North Korea	Unknown	Unknown	
Peru	Unknown	Unknown	
Singapore	1,050	1998/99	Some reported trans-ferred to Myanmar
Somalia	Unknown	Unknown	
South Korea	48	Unknown	
Sri Lanka	Unknown	Unknown	
Sudan	Unknown	Unknown	
Syria	500	2003/06	
Thailand	Unknown	Unknown	
Ukraine	Unknown	Unknown	
United Arab Emirates	Unknown	Unknown	
United States	157	2003/05/06	
Venezuela	Unknown	Unknown	
Vietnam	50	2002	
TOTAL	**7,692+**		

Source: Adapted from Jane's, 2012c.

As can be seen, the Russian trend to expand its customer base continued with the Igla. More of the customers are traditional Western allies or partners. In some cases, e.g. Jordan, the weapons were bought as replacement for destroyed Strela-2 weapons.[18] The largest transfers were to India, Jordan, and Singapore respectively. While Singapore does operate the Igla, there have been rumors that some of these missiles were diverted, presumably to Myanmar, though the Singaporean government reputedly acted speedily to cut off the diversion.

9K338 Igla-S/SA-24 Grinch: The Igla-S is the newest version of the Igla series. It became operational in 2002, and since then has been supplied to a limited number of other countries.

[18] Interview with disarmament expert at NATO on 23 April 2012.

Table 21: Igla-S transfers

Recipient	Number	Date	Comment
Hezbollah	Unknown	Unknown	
India	Unknown	Unknown	Not confirmed
Jordan	200	2008	
Libya	24	2004	In Strelets (vehicular) configura-tion
Malaysia	Unknown	Unknown	Not confirmed
Mexico	5	2003	
Syria	Unknown	2002	In Strelets (vehicular) configura-tion
Thailand	36	Unknown	
Venezuela	100	2009	Number since upgraded to 2,400.
Vietnam	Unknown	Unknown	
TOTAL	**365+**		**2,060 including Venezuela**

Source: Adapted from Jane's, 2012m.

The Igla-S is comparable to the newest FIM92-RMP Stinger in its capabilities. It has been transferred to a limited number of other countries. Much has been made of the transfer of Igla-S to Libyan stockpiles, and their alleged theft and re-transfer to Gaza. However, the missiles identified in Libya are almost certainly all without gripstocks. The Russians claim that a small number of Igla-S were supplied to the Qaddafi regime. However, and this is born out by subsequent investigation (Chivers, 2011b; Peterson, 2011; Schroeder, 2011, p. 18-19) these were in the Strelets configuration, designed to be vehicle mounted.

Copies and reverse engineering of Russian MANPADS: Both the Strela and the Igla family of MANPADS have been copied extensively, and have been models for Pakistani, Chinese, Korean, Egyptian and Iranian versions. Transfers of those weapons are summarized under the headings of the relevant source countries. Crucially, the Soviet government was generally fairly relaxed in permitting the copying of their small arms. The Strela-2 and -3 were copied by Egypt, Iran, and China, and have been transferred to Pakistan and North Korea by the Egyptians for reverse engineering. In addition members of the Soviet block—Bulgaria, Hungary, Romania and Poland—have manufactured versions or (in the case of Poland), reverse engineered the weapons.

Russian transfers to NSAGs:
There is no direct evidence of the transfer of MANPADS to NSAGs by the Russian authorities. The Soviets did transfer MANPADS to organizations that later morphed into official governments. However, these organizations (e.g. People's Movement for the Liberation of Angola, MPLA) were arguably (insofar as the Soviets were concerned, at least) the de-facto government, and so transfers to Angola may not fall under the NSAG label. Transfers to other NSAGs ranging from Hezbollah to the Sandinistas were presumably handled indirectly through Soviet proxies. The breakdown of the Soviet Union also meant that new NSAGs in former Soviet dependencies had access to Soviet stocks (and the skills to use them) because these stocks were located in their newly independent/autonomous national territory. This has been a particular problem in the Caucasus, where a number of NSAGs, including Chechen, Armenian, Ossetian and presumably others, have actively sought and used Russian MANPADS in their struggles. Personnel in those NSAGs are often former members of the Russian military, and their military experience, perhaps with MANPADS, constitutes a major hazard, as the picture of an SA-18 shooting down a Russian helicopter shows (SpotterXY, 2009).

Summary: Russian MANPADS transfers

In historical perspective, the picture of Russian transfers of MANPADS seems to have changed. Initially, the Soviet regime appeared to transfer missiles almost indiscriminately to allies and supporters. Upon the fall of the Soviet regime, the Russian government has taken more responsibility for controlling the transfers of MANPADS. This appears to be due to two different causes. On the one hand, the need for hard currency has meant that, to date, Russia has made more efforts to ensure that its manufacturing prowess is not squandered, and the income from Russian products, including MANPADS, accrues to Russia. On the other, starting with the Afghan war, Russia has found itself subject to many of the same threats encountered by other countries engaged in asymmetric warfare: the threat of MANPADS being one of the most serious. Russia's engagement with the United States in multilateral (UN) and bilateral (MANPADS Discussion Group) fora demonstrates that the Russians have become more sensitive to the potential threat of MANPADS against themselves as well. The publicized downing of a Russian helicopter in the Caucasus (SpotterXY, 2009) by Chechen separatists firing a Russian MANPADS illustrates that threat. From an almost indiscriminate transfer partner, therefore, Russia has become more responsible in providing transfers, albeit not to the degree that is desirable, and not with other states' interests in mind.

It is clear that Russia has become much more amenable to controlling the spread of MANPADS than it has before. For example, under dual American and Israeli pressure, it ensured that the newest Igla-S supplied to Syria was only in the vehicle-mounted version. Russia also claims that its recent transfers include the right to on-site surprise inspections. What does not come through is the degree of political will the Russians have to actually use those instruments consistently. Thus, while the right to inspect Venezuelan stockpiles exists, the Russians claim they see no need: perhaps for fear of political repercussions with the Venezuelan government.

In summary it is possible to say that:

- The picture of Russian transfers of MANPADS is an improving one to date, in terms of the number of items transferred and the number of recipients, both of which have been falling steadily over the past three decades.
- Russian transfers appear to be strongly correlated with Russian political interests. Should tensions with other blocs rise again, it is eminently possible that they will use MANPADS as political tools once again, though given the economic value, it is unlikely they will return to the widespread 'donation' of these arms.
- The legacy problem of older Russian MANPADS remains. While a Strela-2 may not be the best of battlefield weapons, remaining undestroyed stocks still pose a problem to civilian aircraft, most notably because their price has dropped to extremely affordable.

Sweden

Sweden has produced and marketed its RBS-70 and its Bolide missiles in large numbers. Eighteen countries are reported to have received one or another version of the RBS-70. In 2006/07 the Latvian Air Force received a number of RBS-70 systems. A year later, systems were delivered to Finland, supplemented in 2010 by a further shipment worth some US $35 million. The original missile for the system was replaced by the Bolide missile, with the same firing mechanism and casing, but an improved range and performance. There have also been improvements in networking and communications. Nevertheless the system is essentially unchanged and for the purposes of this *brief* the original RBS-70 missile and the Bolide are treated as one. Countries that have received the system are noted in Table 22.

Table 22: RBS-70 and Bolide transfers

Recipient	Number	Date	Comments
Argentina	Unknown	Unknown	
Australia	250	1987/ 2003/ 2007	49 launchers/ 250 missiles
Bahrain	161	1980/81	14 launchers/ 161 missiles
Bangla-desh	Unknown	Unknown	
Brazil	Unknown	Unknown	
Czech Republic	16	2007	
Finland	128	2008	
Germany	16	2007	
Indonesia	150	1982	
Iran	200	1985	
Ireland	20	2007/08	
Latvia	102	2006/07	
Lithuania	281	2004/05	
Malaysia	Unknown	2008	
Norway	5,550	1981/84/87 90-94	
Pakistan	1,205	1986-88/2008	
Singapore	500	1980/81	
Taiwan	20	1984	
Thailand	90	1997/ 2002/05	
Tunisia	300	1980/81	60 launchers/ 300 missiles
United Arab Emirates	304	1980/81	
Venezuela	8	Unknown	no. in service, no import no.
TOTAL	**9,301+**		

Source: Adapted from Jane's, 2012h.

There have been a few minor transfers within this group of recipients (e.g. transfer of individual missiles from Germany to Finland and from Norway to Finland) but this does not change the picture significantly.

United Kingdom

The United Kingdom has manufactured four generations of MANPADS, starting with the Blowpipe in 1975, then the Javelin, the Starburst, and finally the currently manufactured Starstreak. While the Blowpipe was widely sold abroad, British transfers of MANPADS have declined from 11 countries for the Blowpipe, to only one export customer for the Starstreak. Missiles bought by Argentina were used by both the Argentinean Army and the British expeditionary forces during the Falklands war, claiming three successes: one for the Argentineans against a British Harrier fighter-bomber, the other two by the British against slow-flying prop-driven Argentinean Aermacchi MB-339A and Pucara attack craft (Smith, 1989).

Blowpipe: The Blowpipe was an inaccurate and ineffective weapon and was in service between 1975 and 1993 when it was replaced by the Javelin. During that time, Blowpipes were transferred to a number of states. Some 280 launchers were acquired by the United Kingdom itself. Conceivably the purchase of Blowpipes (mainly by former British-influenced nations) was due to the fact that the 1980s were the early period of MANPADS acquisition.

Table 23: Blowpipe transfers

Recipient	Number	Date	Comments
Afghanistan/ Mujahideen	50	1986	Possibly ex-UK; financed by United States; delivered via Pakistan
Afghanistan/ Mujahedeen	300	1987	Probably ex-UK; financed by United States; delivered via Pakistan
Argentina	8	1981	Subsequently used by Argentina in Falklands War
Canada	55	1982–83	Subsequently destroyed and no longer in stock (Canada letter)
Chile	48	1982	Deal incl. also 8 launchers
Chile	50	1983	
Chile	50	1988	
Malawi	70	1985	Deal incl. also 14 launchers
Nigeria	200	1983–84	US $28 m deal
Oman	200	1985–86	
Portugal	60	1983	
Qatar	50	1985–86	
Thailand	100	1981–82	
Thailand	50	1982–83	
Thailand	50	1984	US $1.7 m deal
UAE	100	1981	For Dubai
TOTAL	**1,441**		

Source: Adapted from SIPRI Trade Register 1980–2011

Two of these transfers proved to be problematic. The Afghan weapons were part of a Western program to support the Afghan Mujahideen against the Soviet and Afghan governments' air assets. The Blowpipe performed below standard and was eventually replaced by the US-made Stinger.

Javelin: Javelin was conceived of as an intermediate solution to the problems encountered with the Blowpipe system. The Javelin was exported to a small number of countries: Botswana, Canada, Peru, South Korea, Malaysia, and possibly Afghanistan. The Javelin was in service from 1986 to 1993 when production was terminated and the Javelin was moved, in the British military, into reserve stockpiles.

Table 24: Javelin transfers

Recipient	Number	Date	Comments
Botswana	25	1986/92	
Chile	Unknown	Unknown	
South Korea	Unknown	1986	
Malaysia	12 (or 48)	1991	Number uncertain
Oman	280	1984/90	
Peru	200	1995	
TOTAL	**517+**		

Source: Adapted from Sipri Trade Register 1980–2011 and Jane's, 2012i.

Starburst: This MANPADS, which was the follow-on to the Javelin with some of the characteristics of the more advanced Starstreak, entered into service with the British Army as a Javelin replacement in 1990. Some 250 were supplied to Kuwait, though that number might be a low estimate (Jane's, 2012j). These missiles were supplied with 50 lightweight multiple launchers, a configuration that, while considered a MANPADS, contains three missiles on a tripod, along with aiming and communication mechanisms, which makes it effectively a CREWPADS. Additional sales include 100 missiles to Canada, none of which are currently in service, an unknown number to Jordan, and 504 missiles to Malaysia. Production of the Starburst ended in 2001, and few of the recipient countries count them in their inventories.

Table 25: Starburst transfers

Recipient	Number	Date	Comments
Canada	100	1992	
Jordan	Unknown	Unknown	
Kuwait	250	1995	Incl. 50 launchers
Malaysia	504	1995/97	

Source: Adapted from Jane's, 2012j

Starstreak: Starstreak is the current British MANPADS variant in use. In service since 1997, it has been exported to South Africa in the LML (Lightweight Multiple Launcher) format which can be ground or vehicle mounted, but is not considered man-portable. Eight systems were exported and there is no information on further transfers.

Summary: British MANPADS transfers

The early British MANPADS were well-marketed and sold to a number of export customers. Later on, UK exports of MANPADS declined despite improved models, possibly due to changes in government (Davis, 2002), perhaps attributable to objections by the British public to arms exports in general. There are a number of points worth keeping in mind:

- British MANPADS were sold to Argentina, which used them during the Falklands War (1982) to attack, in one case successfully, scarce British air assets.
- It is possible that by focusing on light multiple launchers and more heavily based missiles, British MANPADS lost some of their market share. On the positive side, this may mean that the newer British missiles are less attractive to NSAGs.

Ukraine

Though the Ukraine does not manufacture MANPADS, it still possesses enormous stocks of Soviet era weaponry, including MANPADS. There is some evidence of open and clandestine export of MANPADS. 50 Igla-1 systems were supposed to be transferred clandestinely to Armenia according to one source (Stratrisks, 2012). According to FAS, Ukraine exported a number of MANPADS missiles, gripstocks, and systems during the years 2003–09 (Table 26). However, and notwithstanding the Ukrainian government's claim that it adheres to the principle of reporting SALW transfer to the UN Register, there is some doubt about the veracity of this claim.[19]

Table 26: Total transfers claimed by Ukraine in UN Register (2003–2009)

Recipient	Type	Number	Date	Comment
Azer-baijan	Strela-3	10	2008	
United States	Igla (SA-18)	29	2003	Missiles
United States	Igla grip-stocks	10	2003	
United States	Igla (SA-18)	29	2005	Missiles
United States	Igla grip-stocks	6	2005	

[19] Government position as communicated in a letter to the authors received from the Ukrainian ambassador on 30 August 2012.

United States	Igla-1	71	2006	Missiles
United States	Igla	99	2006	Missiles
United States	Igla-1	71	2006	Missiles
United States	Igla grip-stocks	18	2007	
United States	Igla-1	120	2008	
United States	Igla grip-stocks	9	2008	
United States	Strela grip-stocks	25	2008	
United States	Strela-3 grip-stocks	18	2008	
Total gripstocks		96		
Total missiles		**439**		

Source: Adapted from Buongiorno, 2009.

The weapons transferred to the United States are intended for one or two purposes: countermeasure/ training for the US military, and destruction. The Ukrainian government and the United States have agreed on the destruction of surplus MANPADS stocks. Regardless of Ukrainian reluctance and later disagreements (Taylor, 2007), some of this overstock has been destroyed.

Summary: Ukrainian MANPADS transfers

Notwithstanding current agreements on the transfer of SALW which many countries support, the reality of transfers may well be different. States such as the Ukraine which possess a large stockpile of surplus weapons as a result of political changes, are inherently tempted to sell those weapons on the free market, notably since they may not feel bound to honor the obligations of their predecessor (in this case, the Soviet Union). Indeed, as can be seen from State Department cables, the Ukrainians agreed to sell Igla missiles for destruction to the United States at market prices (Taylor, 2007).

Moreover, even where states formally adhere to international agreements, there is little enforcement, and, as the rumors from Ukraine indicate, there is always the possibility of clandestine deals and international arrangements. This is not to say that these rumors are necessarily true, but that in the lack of a robust transfer regime, smaller (and even larger) quantities of MANPADS can easily slip through the net.

United States

The United States has had two distinct types of MANPADS: the earlier Redeye, which was the first recorded MANPADS, but which performed with little success, and the later Stinger. Both types of missile were exported. The Redeye, the first MANPADS in service, may also be the first MANPADS to be completely removed from service. An aggressive buy-back campaign, sometimes in the form of one-for-one replacement by the United States and an effective destruction process has meant that few if any Redeyes are available.

The Redeye's replacement, the FIM-92 Stinger, is arguably one of the most successful MANPADS in terms of sales. It does, however, represent a major proliferation problem, as its dispersion in Afghanistan demonstrates.

FIM-43 Redeye: The Redeye was the first MANPADS to be operationally deployed (1967) and showed all the weaknesses of a first generation weapon. It remains unclear how many Redeye systems were produced overall. According to Cagle, 31,268 systems were built between 1965 and 1973, including 2,876 for foreign customers (1974, p.155). Clearly, production continued after that year, as is evident from the various exports between 1974 and 1986 listed in Table 27. However, the number of 85,000 systems produced by 1969, as cited by various Internet sources, contradicts the data provided by Cagle, cannot be confirmed by credible sources, and is very likely to be incorrect. The missile was superseded in US American service by the FIM-92 Stinger in 1981. Foreign sales were robust, though the United States ceased support to the weapon in 1995. Such evidence as is available indicates that, with the exception of Afghanistan and probably Iran, none of these transfers, whatever their volume, are still active.

Table 27: FIM-43 Redeye transfers

Recipient	Number	Delivery	Comments
Afghanistan/ Mujahideen	50	1984–85	Ex-US; aid; delivered via Pakistan
Australia	260	1969–70	
Chad	30	1983	Ex-US; aid against Libyan invasion and Libyan supported GUNT rebels
Chad	100	1986	Ex-US; aid against Libyan invasion and Libyan supported GUNT rebels
Denmark	243	1970	FIM-43C version; Danish designation Hamlet
Germany (FRG)	1,400	1975	FRG designation Fliegerfaust-1 (FLF-1)
Greece	500	1975	
Israel	500	1975	
Israel	882	1977	
Jordan	300	1977–78	
Nicaragua/ Contras	300	1986–87	Ex-US; part of US Fiscal Year 1987 US $100 m aid for Contras
Saudi Arabia	190	1973–77	
Saudi Arabia	310	1979-80	US $6 m deal
Somalia	300	1982	Ex-US; US emergency aid during Ogaden War (between Ethiopia and Somalia)
Sudan	125	1984	Ex-US; emergency aid after border war with Libya
Sweden	1,083	1967–70	US $8 m deal; Swedish designation Rb-69
Thailand	100	1982	Including 20 launchers
Thailand	100	1983	Number delivered could be considerably higher
Turkey	789	1985–86	Ex-US
TOTAL	**= 7,562**		

Source: SIPRI Arms Transfers Database.

Two other transfers of Redeye took place in addition to transfers from the United States. With US permission, Germany transfered 300 Redeyes to Turkey in 1994. In 1989, the Nicaraguan government transferred 10 Redeye systems to an El Salvador NSAG, the Frente Farabundo Marti para la Liberacion Nacional (FMLN). These had been captured by the then-Sandinista government from the Contras NSAG. The CIA had supplied the Contras with 300 Redeyes in 1987.

FIM-92 Stinger: The Stinger (FIM-92) was developed in four main variants, the original basic version (15,669 rounds built); Stinger-POST (under 600 rounds built) Stinger-RMP, in production since 1987 (over 44,000 by 1997), and Stinger RMP Block I which entered production in 1995. Production is at about 700/month which means 126,000 maximum manufactured 1997–2012, though this number must be treated with great caution due to cuts in military budgets world-wide since 2008. To 30 September 1996, 6,584, missiles were delivered or on order for export. In addition, the European production group consisting of Germany, Greece, the Netherlands and Turkey produced 12,000 Stinger-RMPs under license.

The Stinger (all variants) has been acquired by at least 35 countries and NSAGs around the world (Jane's, 2011g). In addition, several states (North Korea, China) and non-state armed groups (PLO, Chechnyan rebels) are suspected of having acquired the missiles in one or another variant.

In July 2009, Raytheon received an order from the US Army on behalf of Foreign Military Sales for 171

Stingers for Taiwan and 178 Stingers for Egypt and Turkey, delivery by 2012. Afghanistan, Algeria, Angola, Iran, Israel (in addition to 344 reported in the Table), Kuwait, Former Yugoslav Republic (FYR), Macedonia, Singapore, South Korea, and Spain received unreported quantities of Stingers.

Table 28: Reported Stinger transfers

Recipient	Number	Date	Comment
Bahrain	14	1988	
Chad	30	1987	
Chile	378		
Croatia	120		
Denmark	100	1991	
	840	1996	
Egypt	100	1991	
	600	2003	
	600	2008	
	178		
France	50	1983	
Germany	4,500	2004	(from European Stinger Consortium)
Greece	1,500 200 432	1994 2004 2006	(+1,100 from European Stinger Consortium)
Israel	344	1996	+ undisclosed number in second shipment
Italy	450	1988	
	50	2002	
	200	2004	
Japan	555	1988	
	232	1991	
	150	2008	
Lithuania	62	2007	Mounted version
The Netherlands	720	1985	
	874	2003	
Pakistan	100	1985	
	50	1987	
Portugal	30	1996	
Qatar	12	1988	
Saudi Arabia	400	1984	
	200	1990	
Switzerland	3,500	1996	
Taiwan	2,027	2001	
	171		
Turkey	469	1992	
	178		
	4,800	2004	from European Stinger Consortium
United Kingdom	100	1982	
	100	2004	
TOTAL	**=26,516**		

Source: Adapted from Jane's, 2012g.

A number of interesting features emerge from Table 28. Stingers are bought by satisfied customers who also upgrade their stockpiles. Thus there is a wave of purchases in the 1980s, followed by further purchases in the late 1990s and mid-2000s as upgraded versions of the weapon are made available. Some manufacturing countries—the United Kingdom, France, and Pakistan—seem to have made small purchases before their own domestic production took off, perhaps more to examine the product than to use them as battlefield weapons.

Transfer of US MANPADS to NSAGs:
Of particular concern are US transfers to NSAGs. In 1987, the CIA transferred some 300 Redeyes to the Contras NSAG in Nicaragua, some of which were captured by government forces. A selection of the captured weapons was then turned over to another NSAG, the FMLN in El Salvador.

The case of some 600 to 1,000 (the numbers are in dispute) Stingers transferred to Afghan Mujahideen by the CIA is of course notorious. The weapons were transferred as a way of disrupting the Soviet occupation of Afghanistan. Though the effect of the missiles is disputed—Russian pilots quickly learned to overcome the threat, and there are strong claims that the Soviet government had decided to reduce its involvement in Afghanistan before the Stingers became a threat (Cordovez and Harrison, 1995, pp. 69–70; Urban, 1988, pp. 225–56)—the transfer has produced concerns that relict Stingers might be used against US forces in Afghanistan.

Stingers in the hands of NSAGs are seen as a threat in two other areas of the world. Jane's (2012g) reports that samples of Stingers have been transferred (knowingly or not) from Egyptian or possibly Jordanian stocks to the PLO and Hamas. None of these reports have provided any evidence to substantiate the claims, though, given the political realities, they are certainly possible. There are some unsubstantiated claims that Stingers have been transferred to Chechen rebels. However, no public substantiation is available.

Summary: US MANPADS transfers

The United States was the first country to deploy successful battlefield MANPADS. US policy on the transfer of MANPADS has also been, officially at least, fairly consistent. MANPADS were largely transferred to reliable allies. To counterbalance that it needs to be said that (a) many transfers consisted of very large shipments; (b) many such 'reliable' allies were politically unstable and thus their alliance value was somewhat hollow, and (c) the United States violated its own stated policies by opening channels for the supply of these weapons to NSAGs.

Starting with the provision of Redeyes to the Contras to the supply of Stingers to Afghan Mujahideen (US supply of Stingers to the FSA in Syria (Reuters, 2012b) is unproven) US clandestine policies and practices seemed to contradict the formal pronouncements. There is little solid evidence of the use of Stingers against Coalition forces in Afghanistan today, but the fear that these weapons will be used against Coalition aircraft is ever present. Moreover, inasmuch as some of the allies proved to be less than reliable, clandestine supplies from former US allies have become a problem on the world market.

Another feature of the US involvement with the transfer of MANPADS is the attempts made by the US State and Defense Departments to recover and destroy obsolete MANPADS, and those in the hands of unreliable groups. This has been an active policy of the United States, and it has been successful in recovering and destroying virtually all Redeye MANPADS, which, however little use they may be on the battlefield, still could constitute a threat to civilian air traffic.

The gray and black markets

Trade in the gray market is legal (insofar as the states in the transaction are concerned) but goes against the spirit, and often the letter of international agreements (see Chapter 5). It includes rarely reported transfers from state entities to NSAGs. Such transfers are dealt with here in a separate section.

The black market concerns trade that is unlicensed and usually illegal, conducted by individuals for profit and violates a number of international agreements and understandings including the United Nations Programme of Action (UN-POA) on SALW, the Wassenaar Arrangement, and in many cases state laws.

By their nature, gray and black market trades are difficult to identify. They sometimes come to light as a result of police action, or in historical perspective. Yet, one can use the rule of thumb often cited by customs officers: What is uncovered is usually ten percent of actual activity. Even though this is not transferrable one-to-one to MANPADS, arguably only a small portion of illicit tranfers will be uncovered. One needs to keep in mind that in the gray market, and particularly the black market which is oriented more towards NSAGs and criminal enterprises, it may be in the interest of states that have uncovered transactions to keep them hidden, for fear of awkward questions and even potential panic affecting civilian aviation and tourism.

The gray market

Unofficial, unreported, and clandestine transfers from state entities have been features of MANPADS proliferation from an early stage. These weapons provide a qualitative edge, at low cost, and in certain situations can be an extremely useful tool. Table 29 provides data on some known transfers. It is by no means comprehensive, and other transfers are bound to have occurred.

Table 29: Known gray market transfers

Source	Recipient	Date	Type	Number	Comments
Egypt	China	1974	Strela-2	small	Given for reverse engineering
Egypt	North Korea	1974	Strela-2	small	Given for reverse engineering
Ukraine	Armenia	2010	Igla	30	Not clear if transfer carried out

Source: Adapted from Jane's 2011b; except Ukraine: Trend, 2012 (all dates are approximate).

The number of such uncovered transfers and their absolute volumes are relatively small, which could indicate either a data gap, or the absence of much movement within the gray market. Either case is plausible. Another feature which becomes evident is that relatively small numbers have been exchanged between technically capable states for the purpose of reverse engineering. Transfers of that type are generally from clients (e.g. Egypt) of original manufacturers (e.g. Russia) to a third party (e.g. North Korea) for copying. This could imply two things, both of which are relevant: either the supervision of the original manufacturer has not been sufficient to limit the distribution of technical knowledge, or the original manufacturer was complicit in the distribution. In the one case, it may be possible to strengthen the supervision processes to avoid repetition. In the other, the lack of political will to impose restraint is worrying, and little more can be done than to attempt to apply pressure on the manufacturing state by diplomatic means.

International clandestine transfers to NSAGs

This section deals with the intentional transfer of MANPADS from a state or para-state agency to NSAGs. (For purchases on the black market by NSAGs—and state entities—please see above.) There are many reports—some confirmed, most not—about transfers of MANPADS from government stockpiles to NSAGs. The most notorious is the transfer of Stinger missiles to the Mujahideen in Afghanistan from CIA stocks. These were intended for use against the Soviet army and its Afghan allies, but later fell into the hands of anti-American NSAGs and are still considered a threat to American forces in Afghanistan. The most recent case is a claim by NBC that MANPADS have been supplied to the rebel Free Syrian Army to counter the regime's overwhelming air power.

Transfers of weapons to NSAGs can be extremely problematic, since NSAGs almost always have poorer stockpile control than state armed forces, and in no case known have their stockpiles met international standards. Moreover, NSAGs are likely to trade favors with their opposite numbers in other conflicts, bringing about an uncontrolled proliferation of weapons such as MANPADS. Finally, NSAG intentions for use are often mixed, ranging from defending themselves against air attacks by their opponents (normally governments) to attacks against civilian airliners in their own countries or worldwide.

The major manufacturing states have generally committed themselves publicly to responsible transfers of MANPADS. However, this needs to be taken in context. During the Cold War, and before the emergence of standards such as the Wassenaar Arrangement, transfers to NSAGs by their various patrons were fairly common. Table 31 summarizes the known transfers, though the table may be partial in both its coverage (which may be low) and the sources and volume of transfers. What is better known is that such transfers often have major implications for civilian air transport safety.

Many rumored transfers of MANPADS appear to be ephemeral. While some NSAGs display technical and tactical expertise in deploying their MANPADS, many do not (or perhaps the rumors of the transfer were simply not true). Afghan Mujahideen proved occasionally adept at using their Stingers against Russian and Afghan government airplanes, reputedly shooting down a number of them over a period of two years (the actual number is in deep dispute, cf. Kuperman, 1999 and Urban, 1988). However, and notwithstanding their prowess and the reputed numbers of MANPADS in Mujahideen possession, there is no concrete evidence of Coalition forces losses in Afghanistan due to Stingers.

Table 30: Transfers to NSAGs

Source	Recipient	Date	Type	Number	Comments	Reference
Eritrea	Islamic Courts Union (ICU)/ Al- Shabaab Somalia	Unknown	SA-18	6	Two used when Belo-russian cargo aircraft was shot down	UN, 2007, p. 15
Eritrea	Somalia (Al-Shabaab)	July 2006	Unknown	Unknown (not more than 30)	Part of a larger weapons shipment	UN, 2006, p. 13
Eritrea	Somalia (Al-Shabaab)	Aug. 2006	SA-6, SA-7	2 + unknown	Part of a larger weapons shipment	UN, 2006, p. 14

Source	Recipient	Date	Type	Number	Comments	Reference
Iran	Somalia (Al-Shabaab)	July 2006	Unknown	45		UN, 2006, p. 21
Iran	Somalia (Al-Shabaab)	Aug. 2006	Unknown	80		UN, 2006, p. 22
Syria	Somalia (Al-Shabaab)	Aug./Sept. 2006	Unknown	3		UN, 2006, p. 26
Bulgaria	Angola (UNITA)	mid-1990s	SA-7	100		Schroeder, 2007a
CIA (US)	Afghan Muja-hideen	1980	Redeye	"several dozen"	Shipped via Pakistan	Cordovez and Harrison, 1995, pp. 69–70.
CIA (US)	Afghan Muja-hideen	(1982-Unknown)	SA-7	Unknown	Through third parties	McMichael, 1991, p. 30.
CIA (US)	Afghan Muja-hideen	(1984)	Blowpipe	Unknown	Bought from the UK	Cordovez and Harrison, 1995, pp. 158–159.
CIA (US)	Afghan Muja-hideen	1986–87	Stinger	Approx. 250 launchers and ~1,000 missiles	Shipped via Pakistan	Cordovez and Harrison, 1995, p. 198.
US	UNITA (Angola)	1986	Stinger	Unknown		Congressional Record, 1987, p. 7557.

One explanation may be that for some reason the weapons are out of commission because of improper storage, though, stored properly, they can last for decades. A second reason could be some cunning plan, keeping the weapons for the right opportunity. Given the fractious nature of the Afghan resistance, this seems rather far-fetched. A third explanation is perhaps that the weapons have all been expended, sold, or given up in buy-back programs. The same argument holds concerning the reports of MANPADS in the hands of Palestinian and Lebanese resistance groups. Neither the PLO in the West Bank nor Hamas (with one recorded exception in 2012) in Gaza have used their stockpile against Israeli planes, even during dire straits such as the 2010 Operation Cast Lead and Pillars of Defense. A recorded successful attack in Lebanon that brought down an Israeli helicopter was apparently by a rocket-propelled grenade (RPG), not a MANPADS as claimed. Certainly one possible explanation is that the many reported transfers to the Palestinian and Lebanese NSAGs have been wrongly inflated and that these groups lack the expertise to properly store and effectively fire them. (For a detailed discussion of the penetration and use of MANPADS in Syria, see Box 3.)

Summary: MANPADS to NSAGs

A number of states have provided NSAGs with MANPADS for political reasons. With a few exceptions, these have not proven to be successful strategies in the long term. The noted exception has been the transfer of Stingers to the Afghan insurgency. Even there, the source state has had reasons to entertain second thoughts about the action. Some general conclusions can be made about the practice:

- There have been proven and rumored cases of MANPADS transfers to NSAGs.
- Though in a few cases these transfers have proven to be an important battlefield weapon. In most cases the value has been dubious.
- Many reports on transfers of MANPADS to NSAGs do not show evidence of use in the field.
- Some NSAGs (and it is difficult to predict which ones would do so) have used MANPADS against softer civilian targets rather than purely military

ones. This results in loss of civilian lives, and may rebound on the supplier if identified as such.
- In two cases at least (Nicaragua and Afghanistan), MANPADS transferred to NSAGs may have subsequently been used against the original supplier.

The black market

Black market channels are obviously an attractive source for NSAGs looking for weaponry, and for states interested in acquiring samples of weaponry either for countermeasure design or for reverse engineering. In the past two decades, a number of cases of attempted trades in MANPADS have been uncovered. Notoriously, MANPADS have been offered for sale in Yemen's open arms markets. Most of these have been stolen or diverted from legitimate shipments. Small numbers of MANPADS have been offered for sale by individual arms merchants, and have come to light as a result of police investigations. Schroeder and Buongiorno (2010b) have detailed a number of transactions and supposed transactions. Much of the data is anecdotal and has little proof. Nevertheless, it appears that small-scale black market transactions do occur.

Two features characterize these trades. First, they are generally small scale, amounting to single or double digit unit transactions of missiles and gripstocks. This implies that they are not intended for use by regular state forces, but by NSAG or criminal groups. Second, many of these transactions are of first or second-generation weapons. There have been few third and later generation weapons offered for sale (or, at least, that have been published about).

Conclusions: The gray and black markets

The gray and black markets represent the most difficult area of research on MANPADS to penetrate. Those engaged in these markets are of course interested in complete secrecy. Nevertheless, from time to time, such transactions do come to light. One can characterize them in two categories: Small individual transfers and large material transfers. Small individual transfers, again, can be divided into state and criminal transfers.

- Criminal transfers can demonstrably be interdicted by proper use of intelligence, buy-back programs, police stings, all originating from political will (whether innate or purchased is irrelevant). In other words, stopping the criminal trade in individual items is up to good police work.

Table 31: Known black market transactions

Source	Recipient	Date	Type	Number	Comments	Reference
Unknown	Liberation Tigers of Tamil Eelam (LTTE) (Sri Lanka)	(1979)–2009	SA-7 and SA-14	Unknown		Moss, 2009
Unknown	Al-Shabaab (Somalia)	(Oct. 2006)	SA-18	(several dozen)		Schroeder, 2007c
Peru (theft)	FARC (Colombia)	2008–09	Strela / Igla	at least seven		Tamayo, 2010
Libya	Hamas (Gaza)	(2011)	SA-24	Unknown	missile rounds without gripstocks; via Egypt	Chivers, 2012
Libya	Hezbollah (Lebanon)	(2011)	SA-24	Unknown	missile rounds without gripstocks; through Syria	Chivers, 2012
Libya	Hamas (Gaza)	late 2011–early 2012	SA-7	Unknown	during or after the Libyan civil war	Benari, 2011

- State individual transfers are more often than not motivated by political considerations. States have the apparatus to move small items (e.g. by diplomatic bag or other means) and if they are willing to do so, there are very few means available beyond disclosure, to stop the practice. Where such transfers by a stockpiling state are against the interests of the original provider state, it is likely that the originating state will have sufficient sanctioning tools to stop the practice. Here the key to stopping the practice is good intelligence, and a political analysis of the interests of the relevant actors.
- Large clandestine material transfers appear to be the easiest to identify, if only in retrospect. In practice, as has been seen, most such state-to-NSAG transfers seem to have rebounded on their perpetrators. Even state-to-state gray transfers have this potential. Here it is likely that publishing information about the transfer and the threat of exposure may well be a potent tool to stop, or at least, limit the practice.

Theft and losses

None of the surveyed countries has published accounts of lost or stolen MANPADS. We assume that where states have a record of poor stockpile maintenance, there will be a certain amount of leakage of MANPADS, even if these weapons are somewhat better protected. One relatively well-documented case is the theft of Strela and Igla missiles from Peruvian arsenals in 2008 and 2009. The theft was a diversion by a ring of Peruvian officials and associated criminals. They were sold, apparently to FARC in Colombia, along with other Peruvian weapons (Tamayo, 2010).

With the exception of major domestic chaos (see Box 3: Syrian MANPADS in the civil war and Box 2: Libyan MANPADS and the Sahel), thefts of MANPADS that have been uncovered seem to be of relatively small volumes. Admittedly, even small numbers of MANPADS in the hands of terrorists could threaten civilian airplanes. However, the evidence seems to be that most MANPADS used by NSAGs against civilian airplanes did not originate from theft, but were either seized during domestic chaos (in e.g. Iraq) or actually came from the gray market, in other words, were transferred clandestinely by a state actor (see Chapter 1).

No state authority interviewed for this study was prepared to admit the loss of MANPADS from their stockpile, which is understandable. However, it is almost impossible to eliminate field training, accounting, and battlefield losses completely. Individual soldiers and teams lose materiel during training on a regular basis. The frequency of such losses obviously depends on training, experience, and many other factors. It is unlikely that many MANPADS have been lost this way, partly because dummies are more likely to be carried in field exercises. Nevertheless, the possibility of losses of individual units should not be discounted. Accounting losses occur when stockpile documentation is insufficiently precise, or inventories are not properly updated. Again, no SALW Focal Point was willing to speculate on such losses, let alone when applied to MANPADS. Where poor accounting and inventory practiced are the case and there is a norm of corruption, it is highly likely that such thefts will go on and MANPADS, as in the case of Peru will find their way onto the black market. Finally, battlefield losses are unpredictable: during battle it is virtually impossible to keep track of expended ordnance, lost weapons, captured weapons, and even accounting (again, varying depending on circumstances). These battlefield losses do feed into the black market (see e.g. Tribune-Review, 2010; Watson, 2012). In the following, we suggest some effects that could contribute to MANPADS losses.

Effects of posture

We speculate that "posture" (the ways in which MANPADS are deployed by a military) can have a direct effect on the security of MANPADS, notably in situations of flux. Thus, a military that disperses it's MANPADS assets widely (as is done in the United States where MANPADS platoons operate at Battalion levels in all arms divisions) and Russia (where MANPADS platoons are integral to air defense units), is more vulnerable to weapons loss under field conditions. Conversely, in military systems in which MANPADS are controlled tightly by units that are under direct control of higher echelons, it is likely that losses would be less. While this rule of thumb has its limitations (training, discipline, etc.), three scenarios need to be kept in mind: a) normal field practice, where losses are investigated, discipline is notably tighter, and the likelihood of either loss of theft lower; b) battlefield use where there is potential for battlefield capture or loss; and c) situations of flux, where authority is broken, and there is the possibility of discipline breakdown, as occurred in Libya. In the latter case, where MANPADS are distributed throughout the military system, unrecorded losses are bound to occur, which might find their way into the black market.

Effects of insurrection chaos

As has been seen in the case of Libya and Syria (see Boxes on Syria and Libya), even a seemingly ordered state can fall rapidly into conditions of political and social anarchy. In such a case, even the most solemn commitment may be of little value. Accounting for the possibility that a state's security and other mechanisms might fail is almost impossible, and most governments would bristle at the suggestion by a patron or supplier. The fact that weapons outside the umbrella of ordered security forces can be used by anyone is a major weakness in securing MANPADS. This need not necessarily be the case. Electronic and other solutions for neutralizing the threat of unauthorized use exist. What is needed is a standard to ensure that these measures are indeed taken to counter the possibility of insurrection.

Effects of corruption

As the Peruvian case demonstrates, theft—through physical action or more likely corruption—is a major threat to MANPADS stockpiles. No administrative system is proof against corruption of an individual or group within the system. However, corruption within a system ought to be one of the major factors affecting the decision to transfer MANPADS to another state. Even the most far-reaching MANPADS transfer standards (e.g. Wassenaar) make no direct mention of the effects of corruption. However, whatever formal processes are displayed to support limitations on MANPADS transfers may well be insufficient, when a state or individuals within a state are willing to make corrupt decisions.

Effects of storage and transportation

Moving MANPADS is another weakness in transfer regimes. While in theory such transfers ought to be well-guarded and well-documented, as for instance the transport of hazardous materials (which MANPADS come under as Class 1, that is, most hazardous). This may not be observed in practice. Two cases illustrate the problem. In 2010, Serbia exported Serbian-manufactured components from Serbia to Vietnam, based on an end-user certificate. The "Leopard" an unarmed and unguarded ship carrying the components was hijacked by pirates, and the contents were to be auctioned off (International Shipping News, 2011).[20] The well-known case of the Ukrainian merchant ship "Faina" is also illustrative (International Shipping News, 2010). The ship, carrying a shipment of tanks, ammunition, and AA guns from Ukraine to South Sudan via Kenya was pirated off Somalia, and the ship held for ransom. The "Leopard" and "Faina" cases illustrate the need for careful securitized shipments of MANPADS.

[20] A copy of the Leopard's manifest specifying "Strela-2 rocket motors and other parts" in the possession of the authors.

Conclusions: Thefts and losses

The stockpiling and transfer chain of MANPADS offer a number of weak points which will have to be dealt with if MANPADS transfers are to fulfill their ostensible purpose: the protection of state forces against aerial attacks. In practice, as we have seen, these weak points can be, or have been exploited to transfer MANPADS to non-state groups. Among the prominent issues is the need for:

1. Proposing universal means of securing MANPADS in the field and in storage against unauthorized possession and use. A combination of electronic and physical measures might significantly reduce the risk of MANPADS diversion, whether it be by carelessness of those keeping them in the field, or due to political shocks.
2. Corruption can not truly be predicted, but better and more rigorous inspections by source countries might go far to ensure that procedures against theft and diversion are sufficient to deter most corrupt office holders from actually pursuing their aims.
3. Transportation is a weak link, and MANPADS must be transported by the most secure (rather than cheap or fast) route possible, to ensure against piracy, theft, or diversion.

Surplus destruction

Destruction is one sure way to ensure that MANPADS are not transferred without control or to undesirable end users. The US government has been at the forefront of attempts to persuade various states owning obsolescent and surplus MANPADS to destroy those weapons lest they be transferred to undesirable NSAGs. It has provided funding, political pressure, and technical competencies to destroying both United States' and Soviet surplus weapons. Other countries—Italy, Germany, the United Kingdom—have supported destruction in various parts of the world. Funding is generally at the government level, while actual destruction activities are carried out by organizations with expertise in ammunition disposal. The NATO Maintenance and Supply Agency (NAMSA now NSPA) is one agency engaged in destroying surplus MANPADS in various countries including Kazakhtstan and Jordan; the Mines Advisory Group (MAG) has done similar work in Burundi and elsewhere. Where possible, local facilities and organizations have carried out the work (e.g. in Ethiopia). All of those projects have been hugely dependent on the political will of the countries concerned. In some cases, the will to engage in destruction has had a commercial aspect. In other cases, political considerations have predominated. Table 32 provides a perspective. It needs to be emphasized that not all destruction projects are listed, as there is no single authoritative list.

We have tried to be conservative about the numbers. For example, though the Tajikistan project involved more MANPADS, we were able to verify the destruction of only twelve. In some cases, e.g. Jordan, where we believe the entire stock of Strela-2 was destroyed (with some components going for recycling) we know anecdotally that 'several hundred' were destroyed.[21] If all were destroyed that would bring the total to an additional 300 or 500 if Strela-3 and early Igla are to be added. To this need to be added the entire US stock of Redeye MANPADS less the 7,500 that were transferred to other countries and may or may not have been expended or destroyed. It is not known whether a similar exercise took place in Russia. However, given the Russian propensity to store obsolete weapons rather than destroy them, this is unlikely. Given the data conservativism we have adopted, it is possible that total numbers of destroyed MANPADS (again, excluding US destruction of its Redeye inventory) approaches the 32,000 touted by the US State Department (McLeary, 2011).

Some issues need to be highlighted. First, as can be seen from Table 32, numbers destroyed vary quite widely, from individual missiles, to several thousands. Second, often destruction projects only destroy non-functioning weapons, some of which are visible in photographs. Third, only older generation missiles—Strela-2 and Redeyes—appear to be on the destruction list. We could find no evidence of newer MANPADS being destroyed.

Motivations for permitting destruction

Data on motivations for destruction are hard to come by, but important if the momentum of destruction is to be maintained. However, piecing together bits of data, including cables from US embassies, photographs, and other sources, there appear to be three main motivations for MANPADS destruction.

Table 32: Known/verified MANPADS destruction projects

State	Date	Type	Number	Agency	Reference
Afghanistan	2007	?	101	ISAF	PM/WRA, 2007
Belarus	2005–08	Strela 2M	29 (+16 planned)		Krol, 2005; RiaNovosti, 2008
Bosnia and Herzegovina	2004	?	6,000	SFOR	Shapiro, 2012; Cukali, 2003
Bolivia	2006	?	?	US Government	Greenlee, 2006
Burundi	2008	Strela-2	104	MAG	MAG, 2008
Croatia	2011	?	1,000		US Department of State, 2011; Rockwell, 2011
Cyprus	2009	Strela-2	324; 101 grip-stocks; 648 batteries	Cyrprus National Guard	Martynyuk and Diaz, 2009
Ethiopia	2010	?	1	RECSA/Ethiopian Police	RECSA, 2010
Hungary	2005/06	Strela-2	1,540		Embassy Budapest, 2006
Liberia	2007	?	45	UN-DDR	PM/WRA, 2007
Libya	2012	?	5,000 approx.	LMAC	Shapiro, 2012
Mauritania	2012	?	141	NSPA/ Handicap International	Avvocato Militare, 2012

[21] Interview with disarmament expert at NATO on 23 April 2012.

Nicaragua	2006	Strela-2	2,000 approx.		Schroeder, 2006; US Department of State, 2005
Republika Srpska	2003	?	1,077	SFOR	Cukali, 2003
Serbia	2007	Strela-2	4,280	Self	Munter, 2008
Sudan	2007	?	21	NI	PM/WRA, 2007
Tajikistan	2012	Strela-2	12		NAMSA, 2012
Uganda	2007	?	?	SaferAfrica	Guardian, 2010
Ukraine	2007	?	1,000	NAMSA	PM/WRA, 2007
TOTAL			**22,849+**		

Some states, e.g. Uganda, Nicaragua and Hungary have destroyed their stocks of early MANPADS because their military assessment sees these missiles as a problem to store, and a possible threat to civilian security while other states, Jordan, for example, are in the process of replacing older missiles with newer ones or have already done so. Finally, a large category of countries views MANPADS (usually obsolete ones) as a potential source of income if sold on the open (officially, the state-to-state) market.

A US government Agency, the Office of Weapons Removal and Abatement (PM/WRA) has engaged some thirty countries in destroying their MANPADS stocks, and provides the most extensive information on such efforts. Combined with other sources of data, this presents a reasonably good picture of the processes involved in destroying MANPADS. Overall, some states recognize the threat of MANPADS and are willing, sometimes anxious, to collaborate with the United States in their destruction, provided funds (and sometimes expertise) are made available by foreign donors (most often the United States). Destruction and capacity-development then take place together, with the US agency contributing to local programs such as Physical Security and Stockpile Management (PSSM). A long list of countries have gone this route.

In other cases, the motivation is effectively pecuniary. Serbia, Ukraine and Yemen, for example, engaged in lengthy negotiations for market-level compensation for their excess MANPADS, with the Serbians even starting negotiations with Egypt for the sale of their remaining surplus stocks.

Resisting destruction: Ukraine and Latin America

Three notable cases—Ukraine, Nicaragua, and Bolivia—who have resisted MANPADS destruction are instructive. The Ukraine and the United States reached an agreement in which the Ukraine would agree to the destruction of 2,000 of its Strela-2, and the transfer to the United States of an additional 1,200 Igla and Igla-1 and their gripstocks for countermeasure testing. In return, the United States believed it would provide US $5 million for a heavy ammunition disposal project the Ukrainians were interested in, while the Iglas would be provided free in the framework of a joint US–Ukrainian study of countermeasures. Effectively, this transfer would be to test the missiles to destruction. The Ukrainians stood firm that all transactions were to be paid for, while trying to minimize the numbers of missiles for both local destruction and countermeasure transfer. The wrangling took six years to settle, with much lower numbers being included (Clinton, 2008; 2009b).

The examples of Nicaragua and Bolivia may have had a different basis. In both countries, the presidents (independently of each other) agreed to the destruction of stocks of MANPADS. Political opposition at home then called the entire project into question after only about half the agreed inventory was destroyed. In both cases, the national parliament voiced serious objections to the destruction of national weapons, in Bolivia to the point of attempts to impeach the president. While financial interests may have been part of the motivation for objections (Nicaragua had been the source of several MANPADS leaks. Schroeder, 2006) interior political wrangling, framed in the ever-touchy Latin American issue of resistance to US domination was very important.

Box 5: Belarus' negotiations on MANPADS destruction

Negotiations on the destruction of MANPADS can be complicated by various considerations. To show how negotiations regarding the destruction of Small Arms and Light Weapons (SALW) and especially MANPADS can go wrong, this Box takes a closer look at the case of Belarus.

In July 2003, the Government of Belarus (GOB) was the first participating state that requested help with securing SALW and the destruction of excess SALW under the Organization for Security and Co-Operation in Europe (OSCE) document on Small Arms and Light Weapons, agreed upon in November 2000 (NA, 2008a). Two projects led by the United Kingdom (UK) were initiated. One project aimed at securing stockpiles and one at destroying excess SALW including MANPADS.

Two years later, in March 2005, the GOB had destroyed 14 Strela-2M MANPADS as a demonstration of its intent to move forward on the projects (Krol, 2005). When in mid-October the UK OSCE delegation asked the GOB about its contribution to the project, it claimed to have been "misheard" and that no MANPADS were to be destroyed. It appeared that Minsk just wanted the OSCE to help secure their excess SALW (Krol, 2005).

By the end of October 2005, the GOB had apparently backpedaled and Aleksandr Khainousky, Deputy Head of the International Security and Arms Control Department at the Ministry of Foreign Affairs said that the UK had focused on stockpile security throughout the past two years and that Minsk subsequently had dropped the destruction of excess SALW because of the lack of donors. Notwithstanding that, the estimated costs of improving stockpile security would have been around US $3.6 million and the destruction of excess SALW around US $800,000. Khainousky also stressed that Belarus wouldn't have any excess MANPADS to destroy, but as a gesture of goodwill, it would destroy 30, including the 14 already destroyed in March (Krol, 2005).

The Belarusian OSCE delegation had originally agreed that the GOB would destroy MANPADS stockpiles, but changed its course after the UK offered industrial shears for the destruction. Different interests within the GOB led to the fact that other options than the destruction of the excess MANPADS were considered. In this case, once MANPADS destruction was off the table, the UK was reluctant to pay for the storage of excess SALW, which, apparently, was the Belarusian side's main interest. Finally in December 2008, the Defense Ministry of Belarus claimed to have destroyed the remaining 15 Strela-2M MANPADS, bringing the total to 29 after five years of back and forth on the matter (NA, 2008b).

The Belarusian case illustrates four major points:

- Political agreement on MANPADS destruction does not necessarily lead to the results hoped for by the donors.
- Stockpiling states will try to use the MANPADS issue to leverage benefits in other areas not connected to MANPADS, but of greater concern to themselves.
- Multiple interests of actors within a stockpiling government can lead to delays or cancellations in destruction programs. Outsiders may have little effect on the ultimate decisions, which are taken for internal power and political reasons.
- MANPADS offered for destruction were obsolete and of no great military use: a pattern that is seen in many SALW buy-back programs.

Marc Kösling

Summary and conclusions: Surplus destruction

- In MANPADS destruction projects, about 32,000 MANPADS have been successfully destroyed—possibly as much as five to ten percent of world inventory (depending on estimate of total stockpiles).
- Most of the stocks destroyed were obsolescent weapons.
- States do recognize the danger in stockpiling obsolete MANPADS and are happy to destroy those, particularly if approached with an appropriate 'sweetener'.
- Not all states have the capacity to destroy MANPADS, and capacity-building efforts, as well as related development of infrastructure and funding for PSSM are a proven tool to help such states overcome reluctance to destroy local weapons.

- A legacy of a military–political ideology that believes in storing all weapons or that views weapons in ideological–nationalistic terms can seriously inhibit MANPADS destruction.
- Buy-back programs such as the United States can backfire, notably when states feel they can get a better financial deal on the open market.

Technology transfer: Reverse engineering, copying, and self-made

A number of technology transfers of MANPADS have occurred in the past four decades since MANPADS first appeared. A transfer of MANPADS technology to another state is generally motivated by an ideology mix (e.g. US transfers to Contra and Afghan NSAGs, and licensing to a European consortium, as well as Soviet licensing to its satellites and allies), economics (e.g. Russian sales to Venezuela), and politics (e.g. Egyptian transfers to North Korea). There are two, rather different scenarios of technology transfers. One, a manufacturing state licenses the manufacture of a MANPADS type to another country (e.g. licensing of QW-1/2 to Iran). The licensee may then go on to subsequently produce a more advanced version of the weapon. Scenario two typically involves the reverse engineering of the MANPADS without the (official) permission of the originating state.

Licensed production

Licensed production of MANPADS has occurred in several cases. The European Stinger Consortium composed of Turkey, Greece, Germany and The Netherlands manufactures Stinger missiles under license from the United States for their own consumption. Some 12,000 Stingers have been manufactured under the provisions of that agreement. The Consortium has a 'no third party clause' which prohibits the export of this weapon without express consent of the licensor, and the missiles were intended for consortium members' own militaries. An export of European Stingers to Italy was approved by the United States. A similar co-production arrangement was made with Switzerland, which resulted in the production of some 2,000 missiles according to our estimates.

China[22] has developed most of its families of MANPADS on the basis of Russian originals. It is not clear whether these were licit copies or reverse engineering. What is clear is that China then licensed production to Pakistan, Iran, and North Korea for manufacture of their versions of Chinese versions of Russian originals. Both the Pakistani Anza Mk II/III and the Iranian Misaghs were developed on the basis of originals and technical specs provided for the purpose by China (Janes, 2012v, w).

The Soviet Union encouraged its allies and dependents to copy its weaponry among other things to ensure a commonality. The Kalashnikov rifle, for instance, has been copied by over fifty countries. To some degree it appears that the same phenomenon caused a spread of manufacture of Russian MANPADS to Bulgaria, Romania and other Eastern European countries which produced the Strela-2 under license, at least until the appearance of the Igla, at which point the Russians became more restrictive in their approach. Nevertheless, Igla-1 have been licensed to Singapore, and both Strela-2 and Igla-S have been licensed for manufacture by Vietnam (Defense Update, 2007).

Other manufacturers have been far more restrictive in allowing copies to be made: Mistral has been copied to some degree by South Korea, though neither the Swedish RBS-70 nor British MANPADS appear to have been manufactured elsewhere. However, India's intention to modernize its ground-based air defense systems, and the likelihood that they will order 5,000 systems will probably involve technology transfer and manufacturing in India (Sakar, 2012).

Reverse engineering and copying

In contrast to licensed production, a number of MANPADS lines have come into existence through reverse engineering and copying. The Egyptians have reverse-engineered the Strela-2 to manufacture the 'Ayn-al-Sakr. Samples of Strela-2s were sent to Pakistan and North Korea intended for technical study, and those countries began to assemble their own (aided by deliberate China technological support). Samples of Stingers that reached China through Pakistan were reverse engineered as well (Donovan, 1996, p. 10). The same is true of Stinger samples that reached North Korea and are apparently being manufactured there (Jane's, 2012g).

Generally, the Russian Strela and Igla families are the most copied—be it licensed or reverse engineered—of all MANPADS. The Polish Grom-1 is heavily based on the Igla-1 (SA-16). Claims that it was actually a licensed production have been disputed by the producers. It seems that a license was denied after Poland left the

[22] In this *brief,* China is used to refer to the territory excluding Taiwan.

former Soviet Block in the early 1990s. There has been some speculation that the Polish intelligence service managed to get access to the Igla design plans, rapidly shortening the development of the Grom. The Grom--2 is an indigenous enhancement of the Grom-1. The CA-94 is a Romanian reverse engineered Strela-2M. The CA-94M is an indigenous improvement of the CA-94. In addition, practically all Chinese MANPADS are reverse engineered and improved versions of Russian missiles.

Implications of technology transfer

Transferring technology of as dangerous a weapon as MANPADS implies a certain lack of control. However robust an end-user regime, losses and unforeseen events are almost inevitable. Moreover, the ease with which some MANPADS technologies have been copied, often by less-responsible regimes, casts doubts on the ability of the world community to fully control the proliferation of MANPADS, or their reaching dangerous actors. Some generalizations can be made.

- Even a moderate technical ability enables an interested actor to copy MANPADS from existing samples (e.g. Egypt).
- Copied weapons are often improved upon, since the copying normally takes place well after the original model has been produced. Examples are the Chinese QW series, the Polish Grom or the Romanian CA-94.
- It is technically feasible to manufacture an operating MANPADS from disassembled parts of one or several existing missiles.

Though MANPADS are technologically complex devices, it appears that there is no serious barrier to reverse engineer any of them. Most cases of reverse engineering have been by state actors who have the resources and will to engage in such a project. However, given the growing availability of off-the-shelf components, as well as the worldwide spread of technical resources, one cannot discount the possibility that **an organization or state with sufficient willpower, time, and funds, would be able to reverse engineer a fairly sophisticated MANPADS.** This bodes very ill for the possibility of controlling MANPADS' spread, and implies the need for broader, more inclusive, and more intrusive surveillance over potential sources of machinery and materials. It *must* be kept in mind that for illegal purposes, a MANPADS need not be of military grade. For military purposes, robustness and compactness are necessary prerequisites. The same may not be true for an NSAG operating outside a battle zone. Airliners in approach are vulnerable over a lengthy part of their descent (see Chapter 1), which is often over populated areas where an NSAG could assemble separate elements that, in a military MANPADS would be unwieldy or impossible to use due to field conditions.

Conclusion

- While not a major market segment in the world's weapons trade, the sale of MANPADS constitutes a respectable income stream, albeit heavily influenced by political consideration.
- The second-hand market for state–to–state transfers is a major issue, notably for states that have economic problems. Ukraine and North Korea have been heavily implicated in sales and attempted sales.
- Problematic recipients of MANPADS include those whose governments—by design, because of incapacity, or corruption—facilitate the transfer of MANPADS to third parties. China and North Korea are prominent in that regard. While most such transfers are state–to–state, in some cases transfers to NSAGs are an enduring and prominent problem.
- The Syrian and Libyan cases demonstrate that MANPADS in particular, are extremely vulnerable to political chaos, which would allow the escape of MANPADS from even the best-guarded stockpiles into NSAG and private hands. Transferring MANPADS to another state almost always constitutes a security risk, since future political conditions cannot be foreseen.
- Some states, even where they have not transferred the MANPADS themselves, have contributed to the uncontrolled proliferation problem by providing either samples of missiles or plans for the development of indigenous MANPADS to other states (e.g. the Soviet Union, Egypt, China). Such technology transfers, both clandestine and open, remain a weak spot in control efforts. Even where states make attempts to protect their technological knowledge, reverse engineering on weapons such as MANPADS is feasible.
- Legacy generation one MANPADS remain a problem even after the emergence of newer weapon types, unless they are carefully destroyed. While such legacy weapons are

not a serious military threat, they nevertheless represent a threat to civil aviation.

- MANPADS mobility and lethality have meant in some cases that manufacturers (such as Russia, the United Kingdom and the United States) have and are facing the threat of their own weapons being turned against them. This could be a motivating point to enhance efforts to reduce MANPADS spread.
- France, Sweden, and the United Kingdom seem to be moving away from developing pure MANPADS, with all the risks associated with such mobile and concealable weapons, to the production of light self-propelled SAMS to fulfill the MANPADS role. These have the advantage of being less susceptible (and probably less attractive) to terrorists as they require a more complex infrastructure for maintenance and aiming.
- Attempts to recover and destroy MANPADS have reduced world stocks by about 30,000. This is a negligible number representing between less than ten and less than five percent of world stocks (the number depending on the starting figure). Nevertheless, these efforts must continue since they focus on less controllable stockpiles, as well as surpluses which can easily be a temptation for theft and redirection.
- The black and gray markets consist of both large and small clandestine shipments and transfers. For the purely black market which is dominated by individual traders, criminal groups, and NSAGs, better intelligence and police work seems to provide the best options for interdiction. Larger state–to–state, or state–to–NSAG transfers remain problematic because states often have the capacity to hide such transfers officially. However, in many cases, such large transfers become known, if only in retrospect. A considered name-and-shame program, or threats to use that tool, might serve as a deterrent for states considering such activities.
- Technical training (see for instance Schroeder, 2007a, b) and capacity-building are likely to help deter theft. Nevertheless, systemic problems (e.g. high levels of state corruption) and transportation weaknesses represent ways in which MANPADS can proliferate uncontrolled. More vigorous utilization of end-user inspection by manufacturers, as well as better transportation regulation could help in this regard.
- The United States' buy-back campaign has been relatively successful. However, like all purchases, it presents a systemic problem. Specifically, if such purchases are seen as economic transaction, the current owners may be loath to relinquish the weapons, feeling they can make a better deal elsewhere. Buy-back campaigns would therefore seem to be most useful when combined with other incentives, and with a vigorous publicity campaign explaining the non-economic value of the buy-back.
- Most more-or-less sophisticated industrial producers would appear to have little problem in reverse engineering MANPADS. If the engineer wishes a MANPADS that is not up to military specs, the problems are even simpler. This implies that technical solutions as well as the political will to develop and deploy them, must be devised to complicate and limit copying.

Michael Ashkenazi

4 Stockpiles

This chapter is intended to provide an overview of the MANPADS stockpile worldwide. Little reliable data, however, is available about world stockpiles. States are notoriously reluctant to disclose the quantities of weapons they possess. We necessarily have had to use extrapolation more than is desirable.

Of as much concern as the sheer number of MANPADS in existence (larger numbers imply greater vulnerability to theft and diversion) is the *quality* of national stockpiles. We are less concerned about safety (protection from unintentional combustion) in this regard than security (freedom from threat by external action), though there is a connection inasmuch as safety accidents can hide security irregularities, and may sometimes be started on purpose to cover up theft or irregularities. As is the case with stockpile numbers, few states willingly disclose security weaknesses, unless these come to light under exceptional public circumstances. Thus our evaluation of the security of MANPADS stocks is dependent largely on what we know of stockpile security in a given country in general, which may not be much.

The objectives of this chapter are therefore twofold: to estimate stockpiles in several key countries, and to estimate the security and safety of those stockpiles.

Method

Generally speaking, a stockpile consists of several categories of ownership that can be expressed in the formula in Figure 10.

Figure 10: Calculating national stockpiles

National stockpile = manufactured weapons + imported weapons – expended (training+operations+destroyed) weapons – exported weapons – leaked (stolen+lost) weapons.

In the case of MANPADS, none of these numbers are indisputably known. The security and safety of stockpiles is as sensitive a topic as stockpile numbers, perhaps even more so. None of the sixteen states that answered our queries would provide any information on thefts, losses, or security & safety, beyond noting that they adhered to OSCE Best Practice Guidelines (see Chapter 5). Methodologically, we must keep a number of issues in mind:

- Even though monitoring of MANPADS transfers (see Chapter 3) is improving slowly, partly because many countries report on transfers to the UN Arms Transfers Register, partly because information on MANPADS constitutes valuable economic data which firms may want to publicize in support of e.g. stockholders, and partly from other sources such as shipping news, transfer reports are rarely complete and not always detailed.
- Based on an analysis of the military doctrine concerned, it is also possible to estimate, with wide margins, what national stockpiles look like. In some states, MANPADS are integrated into every maneuver division (e.g. the United States), in others they are used by specialist units (e.g. New Zealand) which gives an indication of scale and numbers, notably if supported by other data. The unit estimation method is never complete, since other military or para-military formations may also have MANPADS stocks: in the United States the Secret Service, a branch of the Treasury Department is believed to have MANPADS to protect the president of the United States. In Syria, the air force holds an unknown number of MANPADS to protect its bases, in addition to the army whose order of battle (OOB) is relatively well-known, including MANPADS units. It also has to be kept in mind that doctrine does in many cases not translate one to one into reality. Rather, it is an ideal state that a military aspires to.
- Finally, the use of photographic and film evidence provides some clues as to holdings. Some states, e.g. Venezuela, have displayed their MANPADS holdings publicly, and these materials are available on the Internet.

We have assumed that MANPADS stockpiles will be at the upper end in terms of quality of storage (safety & security) but that general storage practices, as made evident by e.g. accident reports, may also provide clues as to the quality of MANPADS storage.

The combination of methods used provides *some* insight into stockpiles of MANPADS. However, our results must be viewed with great caution.

World MANPADS stockpiles

Reports on MANPADS stockpiles worldwide put the number at 500,000 to 750,000 MANPADS (Bartak, 2005; Berman et al., 2011; Schroeder, 2007b). However, this estimate does not appear to have much by way of evidence and stands on somewhat shaky methodological grounds. Given the formula shown in Figure 10, we simply do not know how many operative MANPADS are available in world stockpiles. The estimates below are thus extremely tentative.

Counting MANPADS is not as much an issue as is to assess the state of the stockpiles. And other issues, such as safety and security procedures, transport safety and security, and proper accounting, count for as much, and perhaps more.

The examples of the major stockpiles provided below are intended to demonstrate what we know of one dimension of the problem.

Three of the major MANPADS stockpiles in the world are also the major manufacturers in terms of volume produced, numbers transferred to other countries, and variety of types. These three—United States, Russia and China—own the world's major MANPADS inventories. They also provide us with examples of potential ways to measure stockpiles.

United States

The United States has been manufacturing MANPADS for over four decades. MANPADS are used as a tool of diplomatic policy (viz. Afghanistan and Nicaragua), for domestic security (e.g. protecting the president), as well as a military weapon. MANPADS are deployed in maneuver units of the army and marines, and certain overseas air force bases as well. It is also possible, though unlikely, that MANPADS are deployed by police units in e.g. New York (In From the Cold, 2011). In theory, the widespread dispersion of MANPADS makes the stockpile more susceptible to theft and leakage, though no such evidence has come to light so far.

Manufacturing perspective: 15,669 FIM-92A (Basic Stinger) and just fewer than 600 FIM-92B (Stinger-POST) missiles were produced. The last Stinger-POST rounds were produced by August 1987 (Jane's, 2012g). Thus, around 2,000 Stingers were manufactured per year. If this number is valid for the FIM-92C (RMP) and FIM-92E (Block I), then since 1995, when the RMP entered service, some 36,000 additional units have been produced. Excepting use, losses and theft if any, this would bring the US stockpile to around 50,000. If manufacturing continued between 1987 and 1995 at the same pace, which is possible, the total number would be 66,000.

OOB perspective: Four of the five armed services deploy MANPADS (the Coast Guard being the exception) as a normal part of their Order of Battle (disposition of units and forces and their equipment. There is evidence that the US Secret Service, charged with protecting the president, has a small stockpile as well. Other government-related security organizations such as the Homeland Security department may have MANPADS on their inventories.

MANPADS were counted here on the basis of what is known about US doctrine for the use of MANPADS (US Army, 1984; US Army, ND) combined with the 2012 Military Balance (IISS, 2012).

- All US army divisions have MANPADS assets (72 teams with six MANPADS each in airborne divisions, 60 in armored and mechanized divisions, 40 in light divisions).
- Marine expeditionary forces (equivalent to a division), have 90 Stinger teams with six missiles each,
- Marine expeditionary brigades, 45 teams, and
- a marine expeditionary unit, 15 teams.
- A small number of Stinger teams are assigned to US air force bases in Saudi Arabia and Korea (Jane's "FIM-92 Stinger"; IISS, 2012).

On this basis we estimate the **minimum stockpile** of ready-to-use MANPADS in the US inventory to be **45,078 missiles,** and about one-third that number of gripstocks. This number does not include other government related security organizations' stockpiles, which may number in the hundreds. We would also assume that there are, in addition, reserve stocks which might equal between one-third to equal-to the ready-to-use MANPADS, bringing the total stockpile, by our estimate, to *60 to 90,000* at most.

Photographic and documentary evidence: Neither de-classified documents nor photographic evidence provide any clues as to the size of the US MANPADS stockpile. Some of the documents (e.g. US Army, ND) shed light on the procedures for securing MANPADS in the field, which appear to be relatively redundant and robust. However, an audit by the General Accounting Office of the US Congress indicates that when it comes to MANPADS sold abroad, there has been a proven wide gap between doctrine and practice, in terms of inspection rigor and record-keeping (US General

Accounting Office, 2004). Whether this reflects on US military practice at home as well is unknown.

Theft and accident perspective: "… there are no (publicly) confirmed cases of successful thefts [of MANPADS] from US arsenals" (Schroeder, 2009). US arsenals in general are subject to a multiplicity of physical and other checks, and so the statement by Schroeder would seem to reflect the reality. Nevertheless, it must be kept in mind that the US MANPADS stockpile is widely dispersed, accidents happen, and soldiers are notorious for abandoning weapons on the battlefield under certain circumstances.

While some cases have come to light of **attempted** black market transactions involving Stingers, these were almost always cases of stings conducted by US law enforcement agencies, and do not provide evidence about stockpile quality. While we doubt US stockpiling procedures are perfect, they appear nevertheless to be robust, and no cases of theft or loss in the United States have come to light.

Summary and conclusions: US stockpile

- The overall size of the US MANPADS stockpile is estimated at around 50 to 66,000 using manufacturing data, or 60 to 90,000 using the OOB method, the higher number in each estimate is a product of the reserve stocks factor used, i.e. 50 or 100 percent reserve.
- The US stockpile appears to be widely distributed, including overseas, which would imply a certain degree of vulnerability.
- Oversight of Stingers sold abroad has been patchy, though it is unknown whether lack of oversight is also true of home stockpiles.
- There is no evidence of cases of theft or lost MANPADS from US stockpiles.

Russia

Russia started producing MANPADS after securing plans for the US Redeye. The Strela MANPADS has been manufactured since 1970 when it entered series production, and is still being produced by Vietnam and Serbia under license. Unlike the Redeye, the Strela-2 was never recalled for destruction, though it has been made obsolete in the Russian armed services. Assessing Russian MANPADS stockpiles is also complicated by the number of types produced in that country.

MANPADS are deployed in front-line battalions of the Russian army, and as part of in-depth air defense system for valuable installations and headquarters. There is no public evidence for their presence in Air Force or Strategic Rocket Force bases, but given the Russian doctrine of air defense in depth, one may assume this is the case as well.

Manufacturing perspective: No reliable source provides information on the rate of production for Russian MANPADS. We thus have no real picture of the capacity of Russian MANPADS manufacture. As a rough estimate based on number of Igla/SA-18 produced (roughly 8,500) over a period of 27 years (series production started in 1983, and continued for export until 2010 at least) we get 300/year production, which seems somewhat low (Jane's, 2012c). Given that thousands of MANPADS have been exported in a single tranche, it is to be assumed that production **capacity** is considerably greater than actual year-on-year production. The Igla-S to Venezuela were supplied within two years of contract signature (see Forero, 2010), which implies a production capacity of around 1,000/year.

A second factor needs to be considered as well. In contrast to the United States, Russia rarely destroys old and even obsolete weapons (see Box 5: Belarus' negotiations on MANPADS destruction). Thus the **total Russian stockpile** most likely includes obsolete Strela-2s along with advanced Igla-S, albeit, presumably in second and third echelon (that is, reserve and homeland defense) units or stockpiles. If the Russians have been manufacturing between 300 (the minimum estimate) and 1,000 per year, for domestic purposes, we estimate the total stockpile by this method to be **between 13,300 and 46,000.** The higher number seems more likely.

OOB perspective: The picture for the Russian armed forces is complicated by a number of factors:

First, the Russian armed forces are still in a period of flux. The army is currently being restructured around a brigade-based structure, rather than an army corps and divisional system. Second, Russian military formations of the same type, e.g. motor rifle brigades, might have slightly different structures. Third, we could find no valid evidence of the MANPADS located on Russian navy vessels, and have made an estimate of one team per vessel (excluding submarines)as we did for the United States. Air bases and radars which are likewise protected by layered anti-aircraft assets are unenumerated, but an additional total of some

10,000 missiles would not be unlikely. Fourth, there is no evidence of a Russian program to destroy obsolescent MANPADS such as the Strela family. These may have been sold, destroyed clandestinely, or transferred to Ministry of Interior Border Guard or Interior Troops, which removes them from the purely military OOB, but not from the national stockpile.

In Russian doctrine, every combat battalion is protected by one platoon (we assume three sections/ teams each, with six missiles per team) of MANPADS. In addition, high value targets, air defense assets, radars, and command posts are all protected by teams, or in cases of larger assets, platoons of MANPADS operators.

Basing ourselves on the most recent edition of Military Balance (IISS, 2012), and including surface combatant vessels of the navy (N=185) with one team aboard each, and around 10,000 missiles for high value sites, we estimate the number of ready-to-use missiles at 64,160. To that should be added a reserve stock of between one-third and the ready-to-use number, bringing the current stockpile estimate to 128,320 as a likely maximum. We have assumed that the other Russian government-related security services—the Federal Border Guard Service, the Interior Troops (ODON divisions and OBRON brigades), Federal Protection Service, Railway Troops, and Federal Communications and Information Agency Troops—are not armed with MANPADS. Should that not be the case, then we would need to add around 92 brigades worth of MANPADS (72 missiles per brigade) to an additional number of 6,624 (plus a possible equivalent number in reserve). At a maximum, therefore, we would estimate **Russian stockpiles at 140,000.**

Theft and accident perspective: Problems of securing Russian stockpiles, notably at the manufacturing end, appear to have been endemic (Pyadushkin et al., 2003). While such problems are probably more true of the early post-Soviet period, they likely persist today as well, at least to some degree. Security for existing stockpiles is sometimes poor (see for example RTCom, 2010). The situation in air defense bases which may also contain MANPADS is not much better (see Think Defence, 2010).

We have no direct evidence of thefts of MANPADS from Russian stocks. As in the United States, there have been cases of Russian stings against would-be purchasers (Williscroft, 2006, pp. 197–98). However, given the relative restrictiveness of the Russian media world, such cases as might have happened would not have reached the public.

Russia has also suffered from a number of well-recorded ammunition accidents (cf. Reuters, 2012a; RT, 2011). These have reportedly included artillery shells and bombs, but the presence of MANPADS in such massive depots should not be unlikely. Crucially for this study, it indicates serious deficiencies in Russian stockpile safety procedures. These explosions both complicate the stockpile count, and also may be sources for MANPADS diffusion, as stocks of MANPADS accounted for as 'destroyed in accident' may actually have been stolen either before or after the accident.

Even more so than in the case of the United States, the Russian stockpile is spread over an enormous territory and MANPADS are in the possession of numerous units. This means that vulnerability to theft and diversion are even greater than in the United States, all things being equal. During the immediate post-Soviet period and until the recent military reforms (2010 and after; Rossiskaya Gazetta, 2012), when pay was both late and low, it is possible that MANPADS were sold to non-state groups and individuals as a way of supplementing pay. To add to the problem, Russia has been plagued by a number of rebellions in the North Caucasus, with Chechnya being the most publicized. Many of the rebels are former Russian army veterans who may have deserted with MANPADS, or who may have contacts within the armed forces to acquire them (US State Department, 2008).

Summary and conclusions: Russia's stockpile

- By the manufacturing method, we estimated Russian stockpiles to be a maximum of 46,000. The OOB method yielded a minimum of 64,000 MANPADS. If we assume a 100 percent reserve stockpile, the number would be 128,000.
- There is no evidence of the Russians destroying obsolete stocks of e.g. Strela-2A/B, which may have been transferred to Border Guard and interior troops. If this is the case, the stockpile may reach 140,000 MANPADS.
- Russian stockpiles are widely dispersed and possibly poorly guarded. There is repeated evidence of leakage from SALW manufacturers, which may include MANPADS. There is evidence of poor guard practices of other munitions, and of repeated ammunition explosions, leading to the conclusion that MANPADS may be at risk as well, with possible diversions before accidents.

China[23]

China is the third largest producer of MANPADS with a number of versions of MANPADS, and missiles for self-propelled short-range missile systems. MANPADS are deployed in the PLA (People's Liberation Army), and we assume the PLA Navy (PLAN) and Air Force (PLAAF). The PLA is modernizing, and is in the process of reorganizing more professionally, but it is still possible that MANPADS may be found within the local defense units as well.

Manufacturing perspective: Chinese capacities and volumes for MANPADS manufacture are unknown. We could find no indications of production volumes. Given China's rapid industrialization, and the emphasis on modernizing the PLA, it can be expected that these are similar to the manufacturing capacities of the other two major producers.

OOB perspective: Currently, the PLA ground force is organized into 18 group armies, along with a number of independent units. Maneuver forces consist of approximately 40 divisions and about 43 separate brigades (armor, mechanized, amphibious, and infantry), supported by roughly 42 artillery and air defense divisions and brigades, and various other units.

In addition to the PLA, the PLA Navy has two amphibious divisions.

The PLA Air Force has an airborne army of two airborne divisions plus combat support elements, perhaps amounting to a third division (Blasko, 2005).

In a very detailed report, Andrew (2009) provides details of the air-defense picture for PLA maneuver elements. Every maneuver battalion includes a platoon of three MANPADS teams with six missiles each (Andrew, 2009). We take this to include brigade HQ which is usually battalion size. Divisions include 106 MANPADS controlled by the Divisional Air Defense brigade commander. Artillery brigades are protected by one platoon of 24 MANPADS.

We have no information on MANPADS deployed by the PLAN or PLAAF. For the PLAN, once again we have made the conservative estimate that surface combatants will be armed with at least one team of MANPADS, though this may not be the case for major surface combatants which have more complex air defense suites. There is some photographic evidence that MANPADS are installed on small craft, albeit in a mounted configuration which may or may not be dismountable. The PLAN disposes of some 650 surface ships of various capacities and sizes (IISS, 2012). Assuming one team with six missiles on average (smaller combatants obviously are likely to carry less) we have 3,900 MANPADS deployed. It is likely that both PLAAF installations and those of the Second Artillery Force (Strategic Missile Forces) are protected by, among other weapons, MANPADS. The PLAAF has five SAM/mixed SAM Divisions, 13 SAM/ADA brigades, 10 SAM/ADA regiments, and four SAM battalions (Military Balance, 2012). If these follow the PLA pattern of 106 MANPADS per AD brigade, this represents an inventory of 4,100 MANPADS. The Second Artillery Corps, which is the strategic missile corps of the PLA is organized into 28 brigades (IISS, 2012). Once again we have assumed that each brigade has 106 MANPADS for defense.

The total inventory of ready-to-use MANPADs would thus appear to be around 23,000. Assuming a ready reserve of around that same number, we estimate the **total MANPADS holdings of China** to be around **46,000.**

Theft and accident perspective: In the period 1998–2012, China reported three unplanned explosions at munitions ites (SAS, 2012). Whether this is a case of underreporting or of good management of ammunition stocks is hard to say. There have also been no reported cases of thefts of Chinese MANPADS. Though Chinese MANPADS have been found in individual hands or with NSAGs, these have generally been reported as being the result of transfer from a third party (US State Department, 2008).

Overall, it seems that Chinese MANPADS stocks are well guarded, and appear to be stored with due regard to safety as well.

Summary and conclusions: Chinese stockpile

Very little has been published about China's MANPADS stockpile conditions. The absence of any information may be due to absence of problems, or to a well-controlled press.

- From the OOB perspective, it appears that Chinese stockpile consists of about 46,000 missiles of different types.
- The assessment of the stockpile relies on only one method, as no other information was available.

[23] In this *brief,* China is used to refer to the territory excluding Taiwan.

- There is no information that would suggest this stockpile lacks security or safety, and no evidence of leaks.

The world stockpile picture

Estimating the world's total stockpiles is complicated by the factors noted at the beginning of this chapter: lack of transparency, and absence of reliable data. (Appendix A presents the publicly available data in a table.)

The data for worldwide stockpiles based on published material amounts to 153,341 MANPADS, a number far below the estimates for Russia alone. Individual state stockpiles may be of the order noted in that table, but world stockpile is likely to be several times higher. What is also evident is the paucity of destruction in comparison to stockpiles. While large parts of some stockpiles have been destroyed, the total number of destructions does not even equal the manufacture of new weapons.

Stockpiles standards in practice

Stockpile standards vary enormously, and this is true of MANPADS components as well. Evidence from Russia indicates that SALW and their components are very often open to theft, stored not guarded, and may have been diverted, at least in the past. Stockpiles in other countries have been compromised, as the case of Peru indicates. There is also evidence that Wassenaar Arrangement signatories are lax in exercising their right to full inspection of stockpiles of purchasing countries, with the potential for leakages.

Regime dissolution and battlefield losses

As the cases of Libya and the Soviet Union demonstrate, where a regime dissolves, either for internal or external reasons, whatever stockpile system was in practice is likely to deteriorate fast. The case of GROM MANPADS sold by Poland to Georgia is instructive. 100 MANPADS and 60 gripstocks were sold to the Georgian military. Polish instructors were in Georgia, helping the Georgians attain Wassenaar Arrangement standards for the stockpile when the war with Russia broke out. As the Polish instructors for the Georgian army told the US embassy, "… the Georgians 'completely lost their heads,' threw the GROMS on trucks, and transported them to the battlefield" where they distributed them to untrained military, and to civil defense units with no training whatsoever (US Department of State, 2008). The instructors were able to secure 66 of the missing missiles, but some apparently made their way to Chechen NSAGs.

The Georgian case above illustrates two ways in which MANPADs can enter the civilian/NSAG sphere. First, by uncontrolled distribution of MANPADS during periods of major threat. In a number of states, civil disturbances have been met with widespread distribution of arms to the populace. In the Georgian case, this included MANPADS. And while the number of GROM MANPADS was relatively small, and the Polish instructors were able to recover many of those lost, there is neither indication that all were collected, nor that none other MANPADS were lost. Second, however good their training, soldiers tend to lose munitions in the battlefield. That happens in the case of a military force retreating in panic, as in Georgia, or even during the heat of an assault. And, as the Georgian case demonstrates, these can easily make their way outside the military.

Conclusion

Data about world stockpiles is extremely fragmentary. The use of different estimation methods yields very different results. Most of our conclusions to this chapter are therefore extremely tentative.

- The three largest inventories of MANPADS (China, Russia, and the United States) total a minimax of 160,000~276,000. We prefer to adopt the larger figure largely because we feel that most manufacturers and origin states tend to under report their holdings and transfers.
- The three major manufacturing nations have grossly underreported their MANPADS holdings (as reflected in Appendix A) so we feel safe in adding the total of the three major manufacturers to the Appendix A total (bringing the world estimated stockpile to over 475,000 MANPADS missiles.
- MANPADS stockpile security varies from robust, with few or no losses insofar as we can tell, to dismal, with real or potential leakages of MANPADS into unauthorized hands.
- It is currently impossible to ensure against battlefield losses, and MANPADS on the battlefield remain vulnerable to diversion.
- However strong a MANPADS security regime is, when a government dissolves, and in the absence of the rule of law, MANPADS stockpiles become extremely vulnerable to theft and dislocation.

Michael Ashkenazi

5 Regulating MANPADS

The transfer, and to some degree stockpiling, of MANPADS has been an international concern for over two decades, though the actual weapons have been in service since the early 1960s. A number of bilateral, multilateral, and international agreements exist to regulate the trade. *Inter alia* these instruments and practices also provide a standard for stockpile security. Notwithstanding these, few states appear to have specific legal instruments that regulate the storage, transfer, or use of MANPADS. These are generally subsumed within existing firearm regulations, or are part of the state's military doctrine and rarely open to outsiders. In this chapter we shall survey the principal legal instruments and where possible their actual application. Given the inherent right of self-defense embedded in the UN Charter, the legal trade in MANPADS, as specifically defensive weapons cannot be generally prohibited. The transfer of MANPADS to NSAGs for use as either defensive or offensive weapons is more problematic. Though it appears to be covered by virtually all agreements which prohibit transfer to criminal groups, one work around is to argue that a specific group is not criminal. In other words, the inherently political nature at the base of all these agreements, legally binding or not, is their Achilles heel.

The Wassenaar Arrangement

The Wassenaar Arrangement covers the field of MANPADS and their trade in great detail, and serves unofficially as the 'Gold Standard' of MANPADS transfers, to which even states that are not members of the agreement claim to adhere. The Wassenaar Arrangement is based on an **affirmation** by participating states that they adhere to certain specific **national** controls on the export of arms. With 41 signatories from all continents, the Wassenaar Arrangement (original 1996, "Elements for Export of MANPADS" adopted 2003, amended 2007) is the most robust and detailed arrangement for regulating the export of weapons. Unusually for SALW agreements, the Arrangement devotes a chapter specifically to MANPADS, recognizing their unique and particularly dangerous nature, and mandating special arrangements for the transfer and storage of these weapons.

- The scope includes transfer and retransfer, as well as transfer of development and engineering data (WA, p. 31, 1.2).
- It specifies that transfers are only on a state-to-state basis, and that the exporting government takes responsibility for ensuring compliance to Wassenaar standards of storage and accounting (WA, p. 32, 3.8).
- Exports are to be evaluated based on criteria evolved within the Wassenaar Agreement (WA, p. 32, 3.6) taking into account potential diversion risks in the recipient country (WA, p. 32, 3.6, 3.7), assurances about proper security and accounting practices (WA, p. 32, 3.9) and secure transportation, storage, and use (WA, p. 3, 3.9).

Crucially, securing export of MANPADS in the Wassenaar Arrangement rests on three related processes: the vendor's **assessment** of the recipient's willingness and capabilities to guard against diversion (including theft, etc.); **guarantees** from the recipient with regard to security of the material and the intellectual property; and satisfaction of the demand for **measurable procedures** to ensure weapon physical safety.

The 2000 update detailed *Best Practices For Effective Enforcement,* which contains a series of measures signatories to the Arrangement could employ to ensure compliance. While these are very detailed, and cover most best-practice ideas, they are not binding on members of the Arrangement. The weakness emerges from the terminology used. Source countries are to 'satisfy' themselves that the conditions are indeed attained. As the exchange of positions between Russia and the United States about Venezuelan MANPADS imports shows, 'satisfy' can be read in many different ways, and does not require actual eyeball inspection (Clinton, 2009a). In other words, signatories to the agreement are at liberty to decide for themselves whether recipients fulfill the requirements. In a world of national interests, it is somewhat ingenuous to expect that nations will not further their political agenda within normative statements. Nevertheless, given the often vague and general exhortations in many other international agreements, the Wassenaar Arrangement represents a significant and desirable advance in MANPADS regulation.

The Programme of Action on SALW Control

The UN Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All Its Aspects (POA) does not specifically refer to MANPADS (UN Document A/CONF.192/15). However, since MANPADS fit the parameters used to identify SALW (portability, size, caliber) they can be seen to be encompassed by the protocol as well. The POA's normative focus is the removal of SALW from criminal and insurgent hands. MANPADS are not a quintessential criminal weapon. They are however effective terror weapons, and useful for NSAGs in defending themselves against attacks by state air forces. The dilemma arises from the amorphous and shifting definition of terrorism as a criminal act, in a world where, roughly speaking, one man's terrorist is another's freedom fighter.

Given the unique potential of MANPADS as a mass terror weapon, and the demonstrated use in that role (see Chapter 1), it seems that the wording of the POA is not sufficiently strong where it comes to MANPADS. MANPADS have no utility in crimes for profit. The single criminal use they can be put to is within acts of terror, and subsuming these weapons under the general category of SALW weakens the POA's legal strength in this regard. Some of the weaknesses of the POA have been addressed in a further document, the UN MANPADS Resolution.

The UN MANPADS Resolution

With the weakness of the POA in regard to MANPADS being apparent, and perhaps spurred by a record of MANPADS attacks against airliners (the dramatic and fortunately unsuccessful attack against an Israeli airliner in Mombasa took place in 2002), the UN General Assembly passed a Resolution in 2004 to supplement the POA, thus effectively introducing MANPADS as a discrete item to the POA (UNGA, 2004). It effectively reinforces (without changing) the need to adhere to effective practices in restricting the illicit transfer, unauthorized access and use of MANPADS. As a General Assembly Resolution, and lacking any enforcement mechanism, its power is limited to political pressure. In effect, the Resolution repeats the major items of the POA with reference to MANPADS rather than to SALW in general. It urges all states to adhere to principles of non-transfer to non-state actors, improve national legislation, and enhance national controls on production, stockpiling, transfering and brokering of MANPADS. In the sixty-second session in January 2008, the UNGA repeated, almost word for word and with no major substantive changes, the Resolution of 2004 in Resolution 62/40 (UNGA, 2008). Judging from the content, either political wrangling did not permit advances in dealing with MANPADS, or there was general consensus that these statements were as far as could be reached in the UN forum.

G8 Action Plan—Evian Summit 2003

The G8 Action Plan was agreed in 2003 within the framework of enhancing transport security. An entire chapter is dedicated to MANPADS. The Action Plan is based largely on the Wassenaar Arrangement and effectively is a reiteration of its principles on MANPADS. Two new and welcome elements are introduced. In Item 1.6., the G8 agree to "… exchange information on unco-operative countries and entities;" and to "…examine the feasibility of development for new MANPADS of specific technical performance or launch control features that preclude their unauthorised use."

The degree to which Item 1.6 has been implemented is unknown. Bilateral information exchanges such as the one between the United States and Russia on the issue of MANPADS have been mired in what amounts to protocol and definitional disagreements. We have found little evidence to suggest that electronic or other measures to preclude unauthorized use—some related materials are on the market already (Armatix, 2012)—are being implemented on a regular basis in new MANPADS manufacture, though this will probably develop with time.

The Action Plan was elaborated in the Secure and Facilitated International Travel Initiative (G8, ND). The SAFTI document introduces a number of new elements.

- Work towards adopting the Wassenaar "Elements for Export Controls on MANPADS" as an international standard (Item 9);
- Deter marketing of MANPADS technology to states that do not maintain strong standards for export controls (Item 10);
- Establish a best practices document on optimal methods for securely storing MANPADS (Item 11).
- Develop a method to assess airport vulnerability to the MANPADS threat and effective counter-measures (Item 12).

All four of these items represent a new and welcome development in the realm of MANPADS control. The adoption of the Wassenaar standards on MANPADS—the most far-reaching and detailed available—is a step towards developing a world standard for MANPADS transfers. So too is item 11 of the G8 Action Plan. Together, Items 9 and 11 advance the principle of worldwide standards for MANPADS control a step further. Taken together, these documents recognize in effect that some states are not likely to adhere to principles of controlled exports of MANPADS and that something needs to be done beyond the normal political wrangling and compromise statements that characterize many control measures.

Though the G8 reiterate statements and sentiments that have appeared before, providing specific action plan items is an advance on previous actions. The heavy reliance on the specific provisions of the Wassenaar Arrangement means that there is an operative standard with almost universal standing. What is missing in as powerful a forum as the G8, is some indication of a future roadmap. Given the importance of air transport, and the possible effects of a MANPADS hit on national, regional, and possibly world economies (cf. Chow et al., 2005, and our own assessment in Chapter 6), a detailed, timed roadmap would have been a major step.

OSCE

The OSCE, which has a great deal of political weight as a standard bearer for multilateral security issues, published its first comprehensive paper on MANPADS in 2004 (OSCE, 2004). This followed on a ministerial decision in 2003 (OSCE, 2003). The principles were drawn from the Wassenaar Arrangement's MANPADS paper (cf. WA, 2012, pp. 31–34). The scope of the 'Principles" elaborates on the list provided in the Wassenaar Arrangement. It is also more specific concerning evaluation criteria, specifying that decisions are to be made by senior policy-level personnel, that licenses for MANPADS are to be unique and specific, and that agents must present an End User Certificate (Item 2.1). The principles reiterate the need for technical limiters on unauthorized use of MANPADS (Item 2.4). The document is also more detailed than the Wassenaar Arrangement in specifying that missiles and gripstocks/ firing mechanisms be stored 'far enough so that penetration at one site will not place the second at risk'; continuous 24-hour surveillance; access only by two authorized persons (Item 2.7). As in the G8 Action Plan (G8, 2003 and see above), the Principles call for exporting governments to share information about receiving governments that fail to meet the criteria and regarding non-State entities making attempts to secure MANPADS. Finally, Item 3 requires that participating states ensure penalty provisions for infringement of export control legislation.

Two years later, the OSCE also published an Annex to the *Handbook of Best Practices on Small Arms and Light Weapons* titled "Best Practice Guide on National Procedures for Stockpile Management and Security. Annex C: Man Portable Air Defense Systems (MANPADS)" which provides best practice notes in great detail (OSCE, 2006). Crucially, the brief guide provides chapters on physical security; access control measures; handling and transport; and inventory management and accounting control. In 2008, the OSCE updated its 2004 Principles for Export Controls of MANPADS (OSCE, 2008). While most of the text is borrowed from the 2004 document, some changes are evident. The most important change is the principle that exporting states should confirm fulfillment of the principles by the importing state "…which may include on-site inspections of storage conditions …" (Item 3.6).

The OSCE documents, while based on the Wassenaar Arrangement's MANPADS principles, push the boundary of regulation even further, by specifying how supervision must be exercised. The introduction of the principle of physical examination (even though watered down slightly by a 'by mutual consent' clause) minimizes the gap between the legal requirements and practical realities on the ground. The Best Practice Guide provides a comprehensive set of applicable procedures to secure MANPADS stockpiles.

Asia-Pacific Economic Forum

One article of the Asia-Pacific Economic Forum (APEC)'s Bangkok Declaration (APEC, 2003, p. 3) is devoted to MANPADS. Two things need to be noted. The article is a general statement of principles, summarized presumably from the 2003 Wassenaar Arrangement. The second issue is that, unlike the G8 statement which is principally concerned with civil aviation, or the Wassenaar Arrangement whose motive is security, the APEC focus is on protection from terrorism, and the article is followed by, and clearly oriented towards, the issue of terrorism. In 2005, the APEC leaders once again made a Declaration relating to MANPADS which noted the delivery of MANPADS component pocket guides from the United States, and planning for airport MANPADS vulnerability assessments (MVAs), effectively tying the APEC Declaration to the G8 Action Plan (ABEC, 2005).

The APEC Declarations support but do not initiate measures for MANPADS control. Given that four MANPADS manufacturers (United States, Japan, China, and South Korea—the fifth, North Korea, is not an APEC member) are on the Pacific Rim, one might have expected a stronger statement. Nevertheless, the fact that APEC leaders are aware of the issue, and that that awareness is reflected in official agreements is a positive step.

This was reaffirmed during the 2006 Association of Southeast Asian Nations (ASEAN) Regional Forum ministers' meeting which noted "… the importance of strengthening controls of the transfer of man-portable air defense systems (MANPADS), to help prevent these weapons being acquired or used by terrorist or other non-state groups. The Ministers noted that the proliferation of these weapons to non-state groups posed a threat to international civil aviation and to all countries in the region." (ASEAN, 2006, Item 30).

Commonwealth of Independent States

The Commonwealth of Independent States (CIS), which is a major stockpiler, manufacturer, and exporter of MANPADS, only drew up a coherent MANPADS policy in 2003 (PCOAS/CHS, 2007). Nevertheless, notably after the MANPADS attacks on the Israeli airliner in Mombasa, the heads of states of the CIS agreed in 2003 on a document "On measures to control international transfers of man-portable antiaircraft missile complexes of 'Igla' and 'Strela' types by Member States of the Commonwealth of Independent States" (reported by Ambassador Vrin in PCOAS/CHS, 2007). As result of the document, a common format for reporting on MANPADS holdings and transport was proposed, and then adopted by many, though not all, CIS states. The Document allows for mutual support, reporting, capacity-building and, where necessary, physical assistance in destroying surplus MANPADS. In addition, in a bilateral arrangement (notwithstanding worsening military ties) Russia and Ukraine agreed to exchange information about SA-7 and SA-18 MANPADS exported or imported to their territories within the framework of fighting terrorism (Razumkov Center, 2009).

Many of Ambassador Vrin's remarks as reported in (PCOAS/CHS, 2007) do not break new ground. His suggestion for making MANPADS export decisions at high policy levels, the exclusion of general export licenses in MANPADS transactions, the exclusion of private brokers, all echo statements made by WA, OAS, and OSCE. What is new in the Ambassador's statement is the recognition that MANPADS are considered a major problem, and have been used in combat in several internal CIS conflicts. A final point is worth making here as well. Buy-back programs favored by the United States, appear, in CIS view, to be only partially effective. Ambassador Vrin points out that buy-back programs offer far less per missile than can be received on the black market, and, effectively encourage black market sales.

The fight against terrorism and independence groups within the CIS and with the Russian Federation in particular has been a major spur to attempts to control MANPADS, along with other SALW (Mariani, 2007). The resultant 2003 agreement (see PCOAS/CHS, 2007) driven by Russia cemented this interest. This agreement is bolstered by a set of national legislations adopted by most CIS member states over the period before and since 2003. Presumably, most of these cover MANPADS as well, though we found no evidence of MANPADS-specific legislation. A further problem, evident from Ambassador Vrin's presentation and pointed out by Mariani (2007), is the lack of independent criteria for arms transfers, which seem at all times to be subservient to national political interests. Moreover, the technical ability of some of these states to implement legislation appears to be doubtful, notwithstanding mutual support and aid.

Organization of American States

Basing itself on the UNGA Resolution 59/90 (UN, 2004) as well as on the PoA (UN, 2001), the Organization of American States (OAS) published a General Assembly Resolution during its fourth plenary session in June 2005 dedicated wholly to MANPADS. In previous instances, the issue had been noted by the OAS, without any great detail. AG/Res 2145 (OAS, 2005) provides no new advances in MANPADS control beyond urging member states to "…maintain strict controls…", ban transfer to non-state parties, destroy surplus, and conduct high-level consultations on controlling MANPADS. Perhaps the most important innovation is the inclusion of the International Civil Aviation Organization (ICAO) recommendations for MANPADS control (originally published by the OSCE). These guidelines, published in an Annex to the Resolution, are agreed upon as binding by OAS members. Resolution AG/Res 2145 was further reiterated in 2006 (OAS, 2006) when the General Assembly of the OAS requested the Permanent Council to convene a meeting in 2007 to discuss effective strategies for mitigating the effects of MANPADS.

NATO

The NATO approach to MANPADS regulation is described in a document (NATO, 2004) which details MANPADS activities supported by NATO, without enlarging on any legislative or legal agreements. The document pays special attention to the issue of removing MANPADS—during storage, use and transit—from possible acquisition by terrorists.

African Union

The African Union has recently (March 2012) produced a document which states, among other issues, that the AU has "…noted the support provided by a number of bilateral partners, … including efforts to mitigate the threat of the [sic] Man Portable Air Defense Systems (MANPADS)" (AU, 2012, Item 7). The document also takes note of the dispersion of MANPADS from Libyan stockpiles (AU, 2012, Item 11)

The US–Russia Bilateral MANPADS Meeting

Concerned about the spread and threat of MANPADS, two of the largest producers maintain a bilateral system of mutual information-sharing at the diplomatic level. The agreement—the 'United States–Russia Arrangement on Co-operation in Enhancing Control of Man-Portable Air Defense Systems' was signed by both countries in 2005, and allows the two major manufacturers to share information and concerns about MANPADS proliferation. Most of the meetings under the arrangement are secret, but occasionally the protocols of these meetings have leaked. The transfer of Igla-S MANPADS in large numbers (1,800 announced, 2,400 delivered in practice, to Venezuela; see Chapter 3) raised alarms in the US government (Clinton, 2009a). Three issues were of particular concern. Venezuela (beyond its hostility to the United States) had a history of transferring weapons to FARC guerrillas in neighboring Colombia; the Igla-S is the newest and most potent MANPADS in the Russian arsenal; and the size of the shipment. This concern had been raised earlier, in 2005, when the shipment was first mooted. In September 2009, the United States raised the issue again, focusing on the possibility that MANPADS had been re-transferred to the FARC. The Russians claimed the evidence was fragmentary, and the serial numbers on the weapons would eliminate that possibility (Susman, 2009). In early March, Russian foreign minister Lavrov assured the United States that surprise inspections would be carried out to avoid MANPADS transfers. In a later exchange at the Russia–United States bilateral meetings, this decision was watered down. To the best of our knowledge there is, at present, neither compelling evidence to show that the Venezuelans have transferred any MANPADS to FARC nor any evidence of Russian robust checks, including surprise inspections of Venezuelan MANPADS stockpiles.

The existence of a bilateral mechanism for the control of arms transfers, notably of MANPADS is an important step. It provides a framework within which states who are both suppliers of large amounts of MANPADS and fearful of their use can get together and semi-formally work out better control mechanisms. However, as can be seen from the Venezuelan case, where political interests prevail, even such quiet meetings are unlikely to bring about substantive changes.

National legislation

In most cases we have been able to identify, MANPADS-related legislation is subsumed under the general heading of arms and ammunition licensing and storage regulations. It should be noted that the willingness of states to respond to questions about MANPADS legislation is limited. The International Civil Aviation Organization (ICAO) which numbers most states in its membership managed to obtain 36 responses to a 2007 letter requesting information on steps to counter MANPADS (ICAO, 2007). Responses to our own letter were worse (18 responses of which one did not contain pertinent information). Overall, the ICAO study revealed that most respondents claimed to fulfill either the Wassenaar Arrangement, NATO standards, or the OSCE Practice Guide. In our case, none of the questioned states had specific legal structures for dealing with MANPADS, and all claimed to adhere to Wassenaar Arrangement principles. Overall, it is likely that the picture worldwide is not different, with the control of MANPADS subsumed within national arms control and/or arms and ammunition stockpile legislation.

Only one state—the United States—has specific MANPADS legislation, which is encompassed within the "Intelligence Reform And Terrorism Prevention Act Of 2004". It is the only national legislation we have been able to identify that specifies MANPADS by name, and demands specific penalties (up to US $2 million fine and up to life imprisonment for illicit handling of MANPADS, to death if used in a homicide). The Ministry of Foreign Affairs of the Russian Federation has published a document—effectively a copy of the

OSCE standards—which, however, is not reflected in legislation, so its legal status is unknown (MFA of the Russian Federation 2003).

In other states, MANPADS issues are handled administratively most often within the framework of arms exports, stockpiling or ammunition movement, to which specific administrative guidance in the case of MANPADS is added.

Table 33: International MANPADS Agreements

Titile	Date	Strengths
Wassenaar Arrangement (WA)	1996/2000	- Robust and detailed - Specific MANPADS chapter - Includes transfer, retransfer, and transfer of development and engineering data - Lists export criteria - Update includes "Best Practices for Effective Enforcement"
WA—Elements For Export Controls Of MANPADS	2003/2007	- Updated
APEC	2003/2005	- No specific strengths
UN-PoA (A/CONF.192/15)	2001	- No specific strengths - No mention of MANPADS specifically
G8	2003	- Uses WA as basis - Clause on information exchange about unco-operative countries and entities - Plan to examine the possibility of launch-control-features
CIS	2003	- No specific strengths
UN Resolution A-RES-59-90 MANPADS Control	2004	- Putting the MANPADS issue on the UN stage - Raising political pressure
OSCE Principles on Export Controls of MANPADS	2004	- OSCEs political weight in security issues - Based on WA - Specific evaluation criteria- Based on WA - More detailed on security issues than WA - Penalty provisions for breach of export control legislation
OAS (AG/Res 2145)	2005	- ICAO guidelines for MANPADS control agreed upon as binding
US–Russia Bilateral Meetings	2005 -	- Semi-formal framework of two major MANPADS suppliers to work out better control mechanisms
OSCE Best Practice Guide on National Procedures for Stockpile Management and Security – Annex C Man-Portable Air Defense Systems (MANPADS)	2003	- Best practice notes in great detail
UN Resolution 62/40. "Prevention of the illicit transfer and unauthorized access to and use of man-portable air defence systems"	2008	- No specific strengths
OSCE Principles on Export Controls of MANPADS	2008	- Demands confirmation of fulfillment of principles from importing state by exporting state - Best Practice Guide for Stockpile Management and Security - Best Practice notes specifically for MANPADS

Discussion

From a normative perspective, the universe of legislation against improper transfers and storage of MANPADS is comprehensive. Indeed, as a legal regime, the tools for legislating against mis-transfer of MANPADS are universally available. States and regional organizations have borrowed from available models to develop their own agreements and protocols for ensuring that the illicit trade in MANPADS is restricted, and the licit trade controlled. However, from an empirical viewpoint, the practices mandated by agreements effectively lack enforcement. **As a general rule, states that wish to violate the rules can do so with impunity.**

Looking at international MANPADS agreements from a historical and geographical perspective, we note that international formal action to control and limit MANPADS has advanced incrementally, and is now at a reasonable development stage. Historically, there is now general agreement that a set of criteria for transport, stockpiling, inspection, and destruction are available to those states that care to implement them. Geographically, more and more states are starting to adhere, at least notionally, to the need to deal explicitly with MANPADS. Starting with the Wassenaar Arrangement with 41 members, the OSCE, APEC, CIS, OAS, and ICAO have adopted some practical and legislative measures to deal with MANPADS. In this regard, we would argue that overlapping membership in many of these organizations facilitates the acceptance of MANPADS agreements.

Nevertheless, it seems clear that the legal framework for the regulation of MANPADS is insufficiently universal. This is meant in two senses. First, some regional organizations—ASEAN, AU, League of Arab States—have not published any documents on the topic of MANPADS, though it could be argued that MANPADS may be included in other SALW control issues. Inasmuch as MANPADS are particularly prevalent in countries that are members of those organizations, this tends to weaken the universality of the documents. In a second sense, we have a serious problem of enforcement. Specific provisions in the Best Practice Guides are effectively not implemented in full. This is often the case where national political or economic interests trump the need for safety from MANPADS threats. States that wish to avoid the word or spirit of the agreements do so with impunity, since not only is compliance voluntary, but enforcement is effectively nonexistent, and states can violate the provisions without penalties. With countries that are not signatories to one or another of these agreements, the situation is even worse. As a case in point, Eritrea, Syria, Iran, and North Korea have apparently supplied MANPADS to the Union of Islamic Courts in Somalia. Some of these were subsequently used to shoot down a Belarus cargo plane (UN, 2006). It should be noted that two of the parties involved—Iran and North Korea—have domestically manufactured MANPADS and supplied weapons to NSAGs.

Understandably, the military are loath to provide detailed information on the deployment or security of their MANPADS stocks. Consequently, we have very little information on the regulatory (that is, sub-legislative) aspect of stockpiles or use: How are laws intended to regulate SALW (and MANPADS) actually implemented nationally? A number of national SALW Focal Points contacted during this study merely replied blandly that 'the government of X adheres to all international standards in the export and stockpiling of MANPADS'. While there is some visual evidence of good stockpile processes (e.g. Venezuela cf. Arcesolo, 2009), there are also a greater number of film clips and pictures showing the reverse (see Table 8 in Chapter 3). This implies that actual practices vary considerably, and even where national legislation exists, enforcement may well be patchy at best.

Conclusion

- The **quality** and **detail** of international regulation of MANPADS has improved in the last decade, starting with the most general (UN-PoA in 2000) to the very detailed OSCE Best Practice Guidelines (2006).
- The **spread** of international agreements on MANPADS has also been impressive with many international and regional organizations encouraging their members to adhere to higher standards of MANPADS control.
- The strongest basis for MANPADS control is the Wassenaar Arrangement's MANPADS document, supplemented by the OSCE's Best Practice Guide. Many regional documents make reference to, or strive to adhere, to the standards set by those two documents.
- Not all regional organizations have issued formal statements on MANPADS, let alone outlined standards for their control.
- While the OSCE's Best Practice Guide is highly detailed, all of the documents reviewed here suffer from lack of enforcement and oversight.

- We found little evidence that states (with the exception of the United States) have legislation that specifically refers to MANPADS, recognizing their uniquely dangerous and difficult nature.
- Unfortunately, we also found evidence that some states that are signatories to one or another of the documents described here do not uphold the principles in practice, though they profess to do so.
- Obligations under one or another of these documents are open to interpretation, are not policed, and thus provide a major weakness in MANPADS regulation.

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6 MANPADS countermeasures

Parallel to the emergence of MANPADS as a threat against aircraft (military and civilian), a number of solutions have been developed to counter this threat. Many studies have discussed countermeasures (CM) to protect civilian aircraft against the threat of MANPADS (e.g. Chow et al., 2005; Czarnecki et al., 2005; Choi, 2010; US Department of Homeland Security, 2010). These measures can roughly be divided into **technical measures** (on-board and on the ground) and **behavioral measures** (pilot training, changes in approach and take-off procedures, security practices around airports). These supplement and extend the process of regulating MANPADS by agreements, which can be considered to be 'political' countermeasures.

Military countermeasures are not always appropriate to the civilian sphere. Principally this is because of differences between the craft themselves (war planes are far more maneuverable, cost is less of an issue) and their flight environment (a war zone as opposed to civilian zones in peacetime). Moreover, countermeasures are not 100 percent effective, and cargo planes with countermeasures on-board have been hit by MANPADS (Bolkcom and Elias, 2006, p. 6).

In this chapter, civilian MANPADS countermeasures are described and some of their pros and cons assessed.

Technical countermeasures

Technical countermeasures embrace a variety of devices—some active, others passive, some airborne, others on the ground—to interdict or confuse and misdirect MANPADS fired at civilian craft. The choice and development of countermeasures is against the background of the technical evolution of MANPADS themselves (see Chapter 2), that is, as MANPADS are improved, new countermeasures are required.

The most common guidance method for MANPADS is on-board passive radiation reception in the infrared (IR) and ultraviolet (UV) ranges (see Chapter 2). Most countermeasures therefore concentrate on disrupting this type of seeker. Guidance systems that depend on the missile or the operator identifying a shape—whether command to line-of-sight (CLOS, direct command or laser beam riding) devices (e.g. Starstreak and RBS70) or charge-coupled devices (CCD), which rely on TV imaging as used in 4th generation IR homing missiles (e.g. KimSan91)—are effectively immune to the kind of countermeasure that would work on the Stinger, Strela or Igla series. The crucial lesson to be learned here is that countermeasures must evolve in response to the threat, which itself is constantly evolving. However, all CLOS devices are somewhat difficult to aim without extensive training and are often Crew-Portable Air Defense Systems (CREW-PADS) rather than single-operator MANPADS, and thus less attractive to non-state armed groups (NSAG). The Japanese MANPADS KimSan which relies heavily on imaging via a CCD has not been exported and we have no evidence of any losses from Japanese stock-piles, and so may be less of a threat as well.

It must be emphasized that even in the community of experts on MANPADS countermeasures, there is no agreement that on-board countermeasures are the answer. One expert in the subject, himself a commercial pilot, argues with some later justification from Czarnecki et al.'s study (2012b) that the combination of modern jet aircraft robustness and pilot training means that MANPADS are not as great a threat as claimed (Romero, 2005). Airlines argue frequently that there is no proven general threat in countries such as the United States (Wagstaff-Smith, 2010, p. 29). The degree to which this claim is valid remains to be seen.

Countermeasure technology

Countermeasures for air defense systems are categorized into **active** and **passive systems.** Active countermeasures are for example flares and directed infrared countermeasures (DIRCM) (see below). Passive countermeasures include infrared signature reduction, fuel tank inerting and redundant controls (Schaffer, 1998, p. 78) (see Table 34). The cost of any system is relative to the complexity of technology and effectiveness (Schaffer, 1998, p. 77). The cost of equipping large civilian aircraft with countermeasure technology ranges from US $1–4 million per aircraft (Bolkcom and Elias, 2006; Erwin, 2003). In addition, the cost of operating such countermeasures in terms of fuel and operating costs has been estimated at around US $300,000 per year (Chow et al., 2005). This means that the retrofitting of aircraft with a countermeasure suite has economic implications which must be balanced against threats.

Other systems such as counter–counter missiles or rockets have been considered as well (Cherry, Kramer and Hagan, 1996). For safety reasons, as well as cost, these appear not to be suitable for commercial aircraft.

Table 34: Examples of active and passive countermeasures

Active countermeasures	Passive countermeasures
Missile approach warning systems (MAWS)	Infrared signature reduction
Flares	Fuel tank inerting
Chaff	Redundant controls
Offset decoys	
Infrared countermeasure systems (IRCM)	
High-energy lasers (HEL)	

Source: Adapted from Schaffer, 1998; Erwin, 2003; Kuhn, 2003; Choi, 2010.

Active countermeasures

Active on-plane countermeasures against passive-homing MANPADS missiles can be divided into two major technologies: **Flares/ chaff and infrared countermeasure systems (IRCM)** and **directed infrared countermeasures (DIRCM).** All of these active technologies depend on the presence of an effective missile approach warning system (MAWS) to identify a threat and turn on the countermeasure (Bolkcom and Elias, 2006). MAWS must be able to identify MANPADS launches with a low probability of false warnings, which in one system is reported to be <1,000 flights per false alarm (Hughes, 2004; Ovost, 2005).

All aircraft-borne countermeasures described below have an additional disadvantage: Their weight and attachment to the hull of an aircraft can increase the cost of flight by a significant amount. All these structures create drag and turbulence, increasing fuel costs, which, in the context of flying long distances and multiple flights can add up significantly (Chow et al., 2005). Both ground-based and on-board systems are currently under development in a number of countries (Richardson, 2007; Rivers, 2004). Some are in active deployment.

Flares

One way to deflect heat-seeking missiles is to provide another heat source. Flares are based on this concept, but developed into more complex countermeasures over the past 40 years (Withey, 2010). Modern flares do not just burn hotter than an airplane engine, but can even simulate the spectral signature of a jet engine. Simulations indicate that firing a sequence of flares can bring the hit probability of generation One and Two MANPADS types (e.g. Strela-2/3) close to zero (Jackman et al, 2009; 2010). Using non-visible-light emitting flares would lessen the ability of older generation MANPADS (e.g. Strela-2/3) to hit even slow flying aircraft (Hughes, 2004).

Despite the latest developments in this field, flares are no reliable solution to the threat of missiles more recent than first-generation MANPADS (Whitmire, 2006, p. 40). Moreover, flares are possible sources of environmental pollution, and, of more concern, possible causes for fires if they fall in built-up or wooded areas (Bolkcom and Elias, 2006). Though flare systems have been developed with special attention to civilian flight limitations, they are still not authorized in many national airports (Hughes, 2004).

Advantages
- Comparatively cheap (Chow et al., 2005, p. 19).

Disadvantages
- Some flares constitute a fire hazard, which makes them unattractive to civilian aircraft that land in airports in highly populated areas (Kaiser, 2010, p. 50);
- Ineffective against generation Three and above MANPADS and against any CLOS MANPADS;
- Extra on-board weight, which leads to higher fuel costs;
- High visibility, which raises concerns about calling public attention to the missile threat (Schaffer, 1998, p. 80).

Chaff

Chaff is a cloud of short plastic or fiber sticks or ribbons with a conductive coating. Packed into a container and explosively released, chaff creates a cloud that can confuse radar homing systems (Macfadzean, 1992, pp. 77f). Modern infrared (IR) chaff fabricated from pyrophoric materials can also confuse IR seekers in missiles with a lower risk of fires on the ground than with flares (Chow et al., 2005, p. 18).

Advantages
- Comparatively low fire hazard;
- Low cost.

Disadvantages
- Extra weight,
- Ineffective against CLOS and imaging seekers.

Offset decoys

Offset IR decoys consisting of powerful IR sources on masts projecting from an aircraft frame or the ground have been proposed as decoys. These might cause missiles to miss the aircraft, or at least reduce the effect of the impact. This method is cheaper than flares and avoids the fire risks of burning flares falling to the ground (Bolkcom, Elias and Feickert, 2004; Phelps, 2003; Schaffer, 1998, p. 78). However, installation degrades aircraft performance, and they are expensive to operate. As ground-based countermeasures, they need to be scattered widely and raised on masts, which increases costs and leaves them open to destruction (e.g. by accurate fire from the ground).

Advantages
- Can protect against any radiation seeker;
- Nothing is ejected from airplane.

Disadvantages
- Ineffective against CLOS;
- Cause drag and degrade aircraft performance;
- Possibility of damage from close hit if missile impacts on offset.

Infrared countermeasures systems (IRCM and DIRCM)

IRCM are a more costly alternative to flares, but also more effective with second- and third-generation MANPADS. IRCM jam the IR guidance system of a missile through lamp-based energy. DIRCM are updated versions that use directed IR energy in form of laser-beams (Avihai, 2008; Maltese et al., 2006; Whitmire, 2006, p. 41). A DIRCM system consists of a sensor suite connected through a MAWS (missile attack warning system), a targeting system based on radar or laser, and a laser projector to blind or distract the incoming missile on a flexible turret or an electronically steered array. The active components of the system, including sensors and projectors, must be housed outside the aircraft's hull, contributing to weight and drag during flight.

There is a broad variety of systems on the market or currently being developed, including Elta's MAGIC, Northrop Grumman's Guardian, BAE Systems' JetEye, Thor Systems' Commercial-Aircraft Protection System(C-APS); Zenit's L166C1; Cassidian's MANTA and SAGEM's CASAM (cf. Avihai, 2008; Bolkcom and Elias, 2006, pp. 11ff; Bruno, 2006; Case and Wolff, 2004; Chow et al., 2005, pp. 17ff; Guhl, 2012; Knight, 2004; Taylor, 2005; Vergnolle, 2007). DIRCM systems appear to be far more effective than simple lamp-based IRCM countermeasures, notwithstanding technical problems (Maltese et al., 2006) and, as noted, have been deployed aboard the aircraft of some airlines.

Advantages
- Protection against most MANPADS generations;
- Updateable.

Disadvantages
- Requires an up-to-date library of threat-seeker codes to ensure optimum performance (Whitmire, 2006, p. 42);
- Ineffective against CLOS;
- Cause drag and degrade aircraft performance;
- May cause (temporary) blindness on the ground or to neighboring aircraft crew and passengers (Chow et al., 2005, pp. 19ff).

A summary of the most common active on-board countermeasures can be seen in Figure 11.

Given the high cost of equipping aircraft with countermeasure suites, alternative active countermeasures have been suggested on the ground. Currently, these are based on either high-energy lasers (HEL) or high-powered microwave phased array projectors as the active disruption element, with a sensor array and a command and control center (Grant and Richardson, 2007).

HEL (high-energy laser) systems

A high-energy laser can be used as an anti-MANPADS weapon, as tests by Northrop Grumman's ground-based mobile tactical high-energy laser (MTHEL) show. "A palletized variant of MTHEL, called Hornet, has been proposed for a wholly ground based defense against MANPADS" (Chow et al., 2005, p. 21). One of the advantages of such a system is that it can counter all current technologies and can be upgraded to counter future seeker technology (cf. Chow et al., 2005; Choi, 2010, p. 94). Detailed technical considerations have been described by Porcello (2004).

Figure 11: Comparative utility of on-board countermeasures

Threat type	Proliferation	Countermeasures		
		Flares	Laser	High power laser
Older generation infared (IR)	Very wide	Demonstrated	Demonstrated	Potential
Current generation IR	Wide	Potential	Demonstrated	Potential
Radio control	Limited	No Effectiveness	No Effectiveness	Potential
Laser beam rider	Limited	No Effectiveness	No Effectiveness	Potential
Future IR (imagers)	None	Limited	Limited	Potential

Demonstrated | Limited | No Effectiveness | Potential

Source: Adopted from Chow et al., 2005.

Microwave phased array based systems

Raytheon has developed a microwave system titled "Vigilant Eagle". It projects microwave pulses to scramble MANPADS avionics (Global Security, 2011; Kren, 2006; Vollin, 2006). The system has been field tested and can provide 360 degree coverage to existing airports. It is independent of aircraft, and, according to Raytheon, is ten times cheaper to install and operate than on-board systems. Like the MTHEL concept, Vigilant Eagle is upgradeable to face future MANPADS technologies.

Advantages
- Effective against any generation of MANPADS, artillery, rockets, unmanned vehicles, and other missile threats (depending on configuration);
- Ground-based system could be much cheaper than equipping every airplane with CM systems (Whitmire, 2006, p. 44).

Disadvantages
- System must be secured against ground threats;
- Potential fratricide (Whitmire, 2006, p. 44);
- Full protection only if aircraft is flying both from and to a countermeasure-equipped airport.

Passive countermeasures

Passive countermeasures include a variety of technical measures that, without projecting objects or energy, could make aircraft less vulnerable to MANPADS attacks. This includes measures to reduce the likelihood of a hit by a MANPADS missile, as well as ways to reduce damage should a hit occur.

Infrared signature reduction

Fire-and-forget MANPADS, notably earlier versions such as the very common Strela-2 and the Redeye, home onto the infra-red (heat) signature of jet engines. Finding ways to minimize aircraft infrared signature, notably its jet exhaust, is a useful countermeasure, accomplished by shielding or ducting the exhaust through shielding or mixing cold airstream with hot plume gases. For more advanced MANPADS seekers which also rely on aircraft shape discrimination (e.g. Igla-S and Stinger RMP), IR suppressing paint may offer some protection and may provide a degree of protection against SACLOS and CLOS weapons as well when their targeting sights are IR based (Bolkcom and Elias, 2006, p. 16; Schaffer, 1998, p. 78).

Advantages
- Cheaper than most active CMs.

Disadvantages
- Possible extra weight, depending on the measure taken;
- Reduces hit probability, but does not eliminate it (Bolkcom and Elias, 2006, p. 13).

Fuel tank inerting

To reduce the risk of fire or explosion in the fuel tank, different inerting techniques have been considered and some are already in use. This method would not just reduce the effects of a missile hit, but generally reduce the risk of fuel fires
(Chow et al., 2005, p. 14; Schaffer, 1998, p. 78).

Advantages
- Reduces damage caused by missile hit;
- Generally reduces the risk of on-board fuel fires (Schaffer, 1998, p. 78);
- Low additional weight.

Disadvantages
- Does not reduce hit probability, only damage severity.

Redundant controls

A single missile hit at the right spot could shut down the avionics of an aircraft. Redundant controls with separation of the systems would reduce that risk, and are recommended for aircraft survivability (Schaffer, 1998, p. 79).

Advantages
- Reduces effect of missile hit.

Disadvantages
- Added cost to aircraft construction;
- Cannot be retrofitted easily.

Structural changes

Strengthening the aircraft's wings and structure would seem to offer some potential for resistance against a MANPADS hit. However, the costs of such are likely to be prohibitive. Moreover, most common MANPADS aim at the engines. While some studies have been conducted on the effects of MANPADS strikes on commercial jet engines, structural changes as such do not seem to be the answer (Czarnecki et al., 2012). One conclusion of the Czarnecki et al. (ibid.) physical tests appears to indicate that while fragments from a MANPADS-hit turbofan engine may damage the hull, the engine itself is likely to survive (albeit, inoperable) and the fire set by the explosion will be extinguished by the on-board fire suppressant system. Evidence from actual attacks supports this claim (Kopp, 2003, p. 34).

In summary, engine and airframe structural *changes* could provide improvements for aircraft survivability in case of a MANPADS hit. Current engines are not as vulnerable to catastrophic failure as would be supposed, and even with one engine hit, most aircraft would be able to make a landing, provided crew were trained to that effect. Improved airframe and engine protection would have to be balanced against costs of retrofitting as well as operating costs for the aircraft.

Behavioral, administrative and political processes

The technical countermeasures described above, both passive and active can be paralleled by behavioral, administrative, and political processes. Like the technical countermeasures, these too have to do with (a) reducing the statistical likelihood of a MANPADS being deployed against a civilian aircraft, (b) lowering the likelihood that a MANPADS shoot will actually hit its target, and (c) reducing the damage a hit will cause to the aircraft.

Pilot training

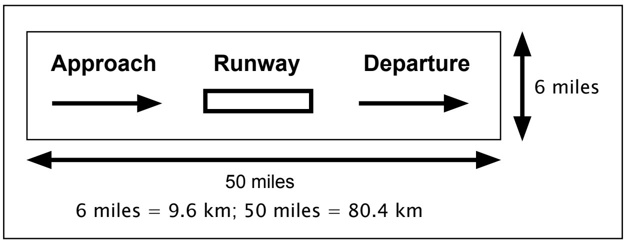
Pilot training for the likelihood of a MANPADS hit may be necessary to ensure an aircraft's survivability. As Romero (2005) notes, commercial crews are routinely trained to deal with more serious damage than a single MANPADS is likely to cause. Nevertheless, the likelihood of survival against the specifics of a MANPADS hit (e.g. spalling from fragments, fire) may be enhanced by simulation training and specific strike scenarios, evasive maneuver training, as well as adapting flight path on take-off and landing (both very steep) to minimize time in the danger zone (Bolkcom, Elias, and Feickert, 2004). McKenna (2006) argues that pilot training may be one of the more important countermeasures employed. The importance of air crew training has been demonstrated by the DHL pilots in Iraq who landed their plane safely after a MANPADS hit. Nevertheless, air crew training can only mitigate the effects of a MANPADS attack, not negate it.

Airport security

With 43,794 airports around the world, according to the CIA World Factbook (CIA, 2012), airports in countries with lax security and porous borders are relatively easily accessible to terrorists who are planning attacks. Even in states that have extensive security arrangements, the impossibility of complete ground security is highlighted by Thompson who states that "protection of approach and departure paths for a single runway could require policing an area of 300 square miles" around every airport (2003). Policing potential launch points is also made more difficult as many airports are in cities with many potential firing locations (Kuhn, 2003, p. 30). Regular, unscheduled helicopter patrols along unpredictable routes, while ensuring minimized air traffic interference, are a measure that may be adopted in regions of known threat. Another possibility is the use of unmanned aerial vehicles (UAV) with MAWS or armed with DIRCM to patrol the skies over airports (Knowles, 2007). Project Chloe, as this system is called, provides advantages in terms of cost (commercial aircraft will not carry the countermeasure equipment) and coverage. However, the tests so far just show satisfying results in blue-sky conditions, because clouds can interfere with the sensors of the high flying UAV (Philips, 2007).

Threat assessment analysis at major airports is now a recognized way of countering MANPADS. This includes an analysis of airport and runway layouts, flight paths and other vulnerabilities (Bolkcom, Elias und Feickert, 2004). Intelligence-led and public participation 'neighborhood watch'-type security systems may also be an element in airport security, as a British police-produced handbook on airport security notes (NPIA, 2011, pp. 67–68).

Figure 12: Airport vicinity vulnerable to MANPADS attack



Source: Adapted from Thompson, 2003.

Stockpile security

Strict adherence to stockpile security standards and management serves to reduce the threat of MANPADS (see Chapters 4 and 5). Commonly enforced standards of stockpile management would reduce the potential risks to the minimal. Destruction of surplus stocks and obsolete systems and missiles coupled with caps placed on national stockpiles, enforced by a world body, would be beneficial though the latter is unlikely.

Within the transfer and proliferation arena, the adherence to, and adoption of, stronger trade regimes such as the Wassenaar Arrangement that also targets the black markets would further serve threat reduction purposes. Past buy-back campaigns to reduce the numbers available outside state control, such as those instituted by the United States may be adopted more broadly, such as in the Middle East following raided stockpiles and proliferation of small arms and light weapons during the 'Arab Spring.'

Shared intelligence

Intelligence has a role to play in foiling future MANPADS attacks or clamping down on black market rings, as the foiled attack on Prime Minister Golda Meir attests. Kuhn (2003, p. 30) also highlights the contribution of intelligence to pilots' awareness and cautiousness. As the MANPADS threat to civilian aircraft is a collective problem, shared intelligence and international cooperation are vital.

One problem with an intelligence-led approach has been highlighted before the implementation of virtual attacks as a terror tactic, which is effective as a PR tool and attention-catching ploy.

Disrupting NSAG training

Disrupting NSAG MANPADS training efforts may be possible, notably if combined with technical devices to limit MANPADS use by unauthorized operations (see below and also Chapter 5: OSCE Best Practice Guide). The availability of training manuals for MANPADS in the public domain means that an enterprising NSAG could, in theory, train its members in MANPADS use (cf. US Army, 1984). Some of these manuals have been translated into e.g. Arabic and are available on the web (NA, 2012). Limiting the availability of such publications may help in controlling the ability of NSAGs to use MANPADS.

MANPADS technical development

The most advanced MANPADS, including the Stinger RMP and the Igla-S, are fire-and-forget systems that require both a gripstock and a missile in its tube to provide a launch. They are heavily dependent on microelectronics and a computerized connection between the elements. "Smart Gun" technology, which restricts a gun's use to an authorized user has been in development for a long time and is being developed by a number of commercial companies such as Armatix[24] and Metal Storm (Hanlon, 2010). Inasmuch as the firing sequence in MANPADS is

[24] For details see: http://www.armatix.de.

controlled electronically via a CPU, "Smart Gun" technology seems to be an obvious next step in ensuring that MANPADS will not be used by unauthorized individuals, or, at least, will make such use much harder, and thus lessen the attractiveness of these weapons.

Discussion

For a complex challenge or threat of this nature, **a multi-pronged approach, targeting the issue from various angles is necessary:** proliferation control and threat reduction; tactical countermeasures; and technical countermeasures (US Department of Homeland Security, 2010). This is necessary as arguably "[n]o level of countermeasures can totally ensure the security of inbound or departing aircraft" (Kuhn, 2003, p. 31).

The development and deployment of civilian MANPADS countermeasures must be seen as a dynamic process: the traditional arms race between the sword and the shield, the attack device and defense against it. Simple MANPADS, such as the Strela-2 and the Redeye could easily be decoyed by flares burning hotter than a jet engine. The Igla-S and Stinger RMP, which use several different targeting methods (IR, UV, imaging, movement algorithms) can only be neutralized or decoyed by more sophisticated multi-spectral measures.

Three other issues need to be taken into account, two technical, and the other economic. On the technical side, "…"[t]here are no technologies that will enable combat aircraft to overfly enemy territory with impunity …" (Puttre, 2001). This observation is even more true of larger and slower civilian aircraft when faced by MANPADS: no technological solution can provide absolute immunity.

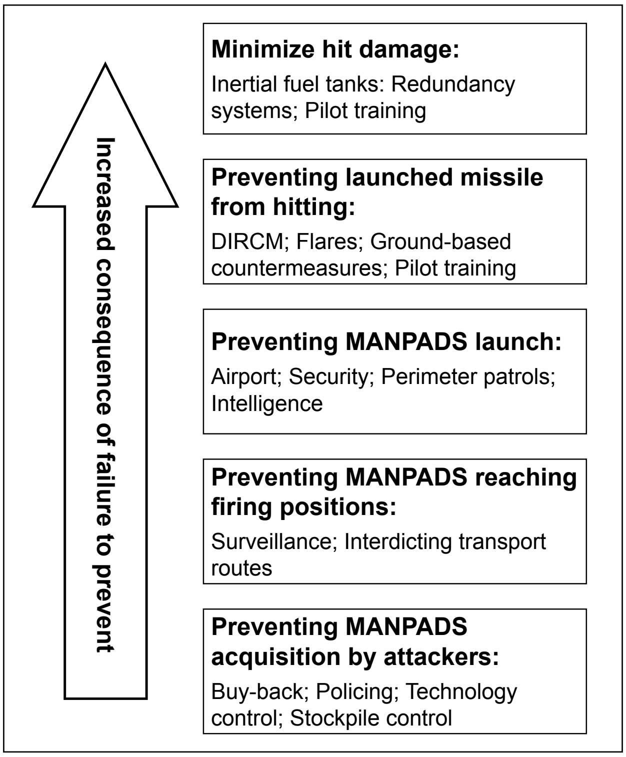
Second, all active countermeasures have the potential for collateral damage. Thus the fear of flares igniting fires in civilian areas have meant that they are generally not useful for civilian use; DIRCM systems may blind people on the ground (or other pilots), and DIRCM-carrying unmanned aerial vehicles (UAV) may interfere with airport traffic. In other words, the damage that a countermeasure can cause must always be balanced against the MANPADS threat. As Chow et al. (2005, p. xi) note, well-financed terrorists would be able to plan attacks so as to defeat any technical countermeasure. Thus the value of technical countermeasures on their own is highly doubtful in the long run.

Third, economically, on-board countermeasures are expensive, with a unit cost of US $1 million and up. This must of course be balanced against risk: the cost of a shot-down civilian aircraft would be high, though we disagree with the figure of around one billion euro, and collateral losses rising to over ten billion euro, suggested by Chow et al. (2005). Nevertheless, states and airlines are loath to bear the costs of fitting all their aircraft with countermeasure pods. One possible partial solution is the Elta one in which a countermeasure pod is attached (or not) according to the degree of threat assessment for that particular aircraft and its destination(s). Civilian airlines also promote non-technical solutions, some of which have been described above inasmuch as they appear to be as effective, but far less costly than technological solutions (McKenna, 2006).

Layered countermeasures

If there is one major realm of agreement (including those opposed to on-board countermeasures such as Romero) about MANPADS countermeasures, it is that protection against MANPADS must be layered (Liams, 2006). Chow et al. (2005, p. 14) for instance, emphasize the multi-layered nature of countermeasures as follows:

Figure 13: Multi-layered countermeasures



Source: Adapted from Chow et al., 2005.

A statistical model to test two parameters—attacker's characteristics (weapon and location) and defender characteristics (active countermeasures and actions) indicated that lower hit probabilities were associated with the use of on-board countermeasures combined with securing the airport's environments (Okpara and Bier, 2008). These findings strengthen the validity of Chow et al.'s 'layered countermeasures' model. The choice of which of Chow et al.'s elements to emphasize, if at all, depends on a number of different parameters, and requires careful modeling and analysis, since it is likely to be different from airport to airport, and between countries (cf. O'Sullivan, 2005).

Conclusion

There is still disagreement about the level of threat MANPADS represent for air traffic worldwide (Czarnecki et al., 2011b). It is generally agreed that air traffic within conflict or war zones makes civilian aircraft into targets. At the other pole of the threat continuum, it is generally agreed by airlines and by many civilian airline pilots (though not necessarily by security agencies) that the threat in the United States and Europe is minimal due to the difficulty of deploying MANPADS in those countries. In other countries, the threat presumably varies depending on the NSAG concerned (some will attack anywhere in the world, others are strictly local) and the security abilities of airport and country concerned. Nevertheless, a single successful attack on a major commercial airline anywhere in the world will have major ramifications. This background dictates some of the conclusions that can be reached.

- Overall, layered countermeasures involving focused efforts at interdiction, intelligence, behavioral, and technical countermeasures are considered most effective.
- Due to the constant evolution of MANPADS for military purposes, civilian technical countermeasures must constantly improve and evolve as well, inasmuch as different countermeasures work on different generations of MANPADS.
- There are material and technical costs for the installation of technical and other countermeasures which must be counterbalanced by the enormously high costs of failure to protect against even one successful commercial passenger aircraft shoot-down.
- On-board, directed infrared countermeasure (DIRCM) systems, which are flexible and upgradeable, are likely to replace lamp or flare systems, though their high cost of >US $1 million are prohibitive for large aircraft fleets.
- Airport technical countermeasures (both high-energy laser (HEL) and microwave-based) are overall cheaper to install and operate, but can provide an answer end-to-end only for flights originating and ending in a protected airport, in practice, within North America and Europe.

Discussion, conclusions, and policy recommendations

General discussion

The core of this *brief* has been, in effect, to look at three central questions.

- What factors support or hinder MANPADS attacks against civilian aircraft?
- What are the effects of a MANPADS attack?
- What tools are available to limit or halt MANPADS attacks?

In this section, we address each of these three questions in turn, drawing on material and conclusions from all the previous chapters. We thus provide a cross-cutting picture from the technical, through the economic to the political.

Attacks against civilian aircraft

Ideally, a complete survey of MANPADS attacks would provide an answer to the five basic questions: When, Where, Whom, How, and Why? In practice, the answer to all of those questions in the aggregate is difficult to assess within the framework of open-source research. Even the seemingly basic questions of when and where are sometimes arguable, as we discussed in Chapter 1: Some crashes supposedly caused by MANPADS might have been due to mechanical failure (e.g. Angola 1983). Virtually all attacks against civilian aircraft were carried out by NSAGs, but it is likely that their motives and the presence of false claimants could put some of those claims into doubt. The "How?" too, is difficult to assess as a generalizable question. **Most MANPADS attacks were carried out using Strela-2A/B so these particular weapons are implicated as a major risk.** More advanced MANPADS have been seen in the hands of NSAGs (e.g. in Chechnya) but whether they are more effective in hitting aircraft is open to question, since the training (or lack of it) variable must always be considered. The "Why" question is problematic as well. Generally speaking, MANPADS attacks can be classified under the heading of 'terror activities' that is because most attacks against civilian aircraft have been carried out not against military targets (by definition) but against civilian targets with the overt intention of publicizing a cause and/or causing fear in an opponent's civilian population and civilian support. Nevertheless, some MANPADS attacks, such as the one against the presidents of Rwanda and Burundi in 1994, had an overt political motive. Others, such as Baghdad 2003, were against civilian aircraft carrying military or quasi-military cargo.

Going beyond the data gaps, however, some generalizations can be made: Older MANPADS, specifically the Strela-2, constitute the major hazard. This is not because they are technically sophisticated but because they were developed and marketed during a period in which the two major powers were supporting their allies and dependents without much regard to the future. This experience *should* raise a red flag: **indiscriminate distribution of MANPADS will most likely turn against the providers.** Still, older MANPADS, including the battery coolant units which were supposed to have been the Achilles' heel of a MANPADS system, are far more durable than expected. Even old MANPADS, imperfectly maintained, can still be operated. This implies that a concerted and expensive campaign would need to be mounted to dispose of all these weapons.

While the actual number of MANPADS worldwide is in question, their general ubiquity is not (see Appendix A). Given the argument that some 47 NSAGs possess MANPADS and have the apparent motivation to use them, we should be asking why MANPADS attacks are not more frequent. A number of complex, not mutually-exclusive answers occur, and may be worth exploring in greater detail:

- MANPADS in the hands of NSAGs may not have all the necessary components; as the early Syrian evidence may show. If this is the case, it is a tribute to the idea of separating MANPADS components (rounds, gripstocks, and batteries) as a security measure.
- MANPADS may be difficult to use and deploy. Evidence from Afghanistan is contradictory, but at least one writer (Urban, 1989, p. 270) indicates that the Mujahideen were not terribly effective at using the Stingers they had been given.
- Politically, the ownership of a MANPADS may well be a better threat and political statement of puissance than a useful weapon. NSAGs such as the Syrian rebels may feel that having a live MANPADS on display is a better card in the internal struggle for prestige, recruits, and support than an expended MANPADS tube which may, or may not, hit its target. Indeed, as the Syrian evidence shows, use of MANPADS only occurred after capture of large numbers of these weapons from Syrian army arsenals.
- Continuing on the previous point, better organized and more sophisticated NSAGs such as e.g. Hamas and Hezbollah may recognize that attacking a civilian aircraft would likely be detrimental to their cause, and very likely

precipitate major military action against them with few political gains and much political loss to be made.

Turning to the targets—the aircraft themselves—we can see that world political changes may have lessened the likelihood of MANPADS attacks. The heyday of MANPADS attacks in terms of numbers per year was in the last quarter of the 20th century. Since then the frequency has gone down. This may be due to the fact that most of the major anti-colonial wars have died down, and thus the motivation for attacking aircraft, and the numbers of groups willing to do so, has declined. It is also possible that improvements in aircraft safety, increase in countermeasures, and evidence that jet aircraft can survive MANPADS attacks have dissuaded some potential attackers. Finally, changes in the world arms regimes, improvements in stockpile security and safety, and layered MANPADS countermeasures may be more effective than given credit for.

Limiting MANPADS attacks

A great deal has been done in the previous decades to limit the likelihood of MANPADS attacks against aircraft. Yet a great deal remains to be done. In principle, limiting MANPADS attacks is a combination of efforts in many fields: diplomatic, legislative, operational, and technical. Perhaps the greatest advance is conceptual: the recognition that limiting MANPADS attacks is a *layered* process, involving each of these fields. It is recognized by all that **it is impossible to provide 100 percent security against MANPADS attacks.** Posing the issue in the form of probability has the benefit of recognizing that each individual 'layer' (see Chapter 6) is a contributor to defense, rather than a determinant: each layer adds to the probability that an attack will be foiled. Activity in each layer degrades the ability of a MANPADS-armed attacker to successfully intercept an aircraft. We examine below this principle with relation to the levels proposed by Chow et al. (2005) and slightly modified by us.

Preventing MANPADS acquisition by attackers

Much of the international diplomatic activity concerning MANPADS has been concerned with keeping the weapons from reaching the hands of attackers. International and regional instruments have been provided, as well as practical processes to ensure the security of MANPADS in stockpiles and in transit. Legislatively, the picture is less rosy, with only one country actually providing legislation to control MANPADS (the United States). Operationally, too, there is evidence of shared intelligence and sting operations of international scope, intended to ensure the same end. The US-led buy-back and destroy program has succeeded in destroying some 30,000+ MANPADS, in addition to the almost total recall and destruction of the entire Redeye inventory. Finally, improvements in PSSM (physical security and stockpile management) may mean that, for example, the separation of gripstocks (and ideally batteries) from the missiles will restrict the potential use of stolen or misappropriated MANPADS to some unknown degree.

In practice, the picture is less rosy. In the diplomatic arena, some of the major manufacturers—China, Iran, North Korea—are not signed up to the Wassenaar Arrangement which can be viewed as the "Best Practice" standard. Critically, there is no mandatory reporting system to the Arrangement, and there is no enforcement of the guidelines, which remain in effect voluntary, with a very high standard of proof for even 'name and shame' activities. To add to the problem, legacy Strela-2s—unreliable, with little counter-countermeasure ability, small warhead and all—remain commonly available, and still constitute an unknown level of threat (given survival rates of modern aircraft, countermeasures, etc.). Attempts to destroy these weapons have reduced them by less than 10 percent of the total world inventory, and an unknown percent of the Strela-2 inventory, about which much more must be known. It is also to be hoped that lessons have been learned by manufacturing powers about the widespread distribution of MANPADS to 'allied' NSAGs, some of which seem to turn against the provider.

In the technical arena, the policy of improving stockpile security by separating components does not mean that MANPADS are no longer stolen. Nor do good MANPADS policies and practices guarantee that MANPADS will not reach a civilian populace when a regime fails, as happened in Russia, Libya and Syria, but it does seem to have limited the usability of MANPADS. And while older MANPADS might be usable without the original gripstocks, using jury-rigged batteries and stocks, newer MANPADS that are heavily dependent on computerized functions in the gripstocks are far less so. Finally, a policy of preferring CREWPADS to MANPADS may make the weapons less attractive, and more difficult to transfer through borders.

Preventing MANPADS from reaching firing positions

Substituting CREWPADS for MANPADS would have a marked benefit in that the larger, more bulky, crew-operated weapons are easier to detect by anti-smuggling and police activities than smaller MANPADS. In this case, the civilian defense against MANPADS benefits from what appears to be a steady military development of the weapon. In addition, procedures for MANPADS defense, including intelligence cooperation, security surveys of airport approaches, and the installation of surveillance devices has limited potential attackers' options: it seems unlikely anyone could successfully replicate the attempted attack against an Israeli aircraft in Italy in 1973 by simply driving up to the airport fence to fire MANPADS.

Yet in poorer countries, airports are less well served by these technologies and practices. In effect, many airports in less-developed countries are likely to be vulnerable to attack. Under conditions of growing national or international tension, it is possible that an NSAG team could approach an airport unseen with its MANPADS as happened in Mombasa, with possibly dire results.

Preventing MANPADS launch

The age of more commonly available MANPADS and subsequent degradation of their components is working in favor of an unsuccessful launch of these models. Nevertheless, we have seen that even components such as batteries last well beyond expectations. Obviously, early identification—through intelligence or technology—of a MANPADS launch also plays an important role in the possibility of limiting the effects of a launch.

A technological solution—such as coding gripstocks electronically to limit firing to authorized personnel—is feasible, and perhaps ought to be considered as an addition to the Wassenaar Arrangement protocols for MANPADS. This would not stop all launches, considering the prevalence of older models, but would definitely restrict launches of more advanced (and deadlier) MANPADS in the future.

Preventing launched missiles from hitting

Preventing a launched missile from hitting its intended target depends on a number of variables (see Chapters 1 and 6). On-board passive countermeasures have the advantage of low cost, and the disadvantage of relatively lower effectiveness. Active countermeasures such as flares are effective only against some types of MANPADS. DRCM measures cover a wider array of threats, but are expensive to install and to operate. Land-based countermeasures are really effective only for aircraft flying from and to countermeasure-equipped airports, meaning in effect, in richer countries only.

Minimizing hit damage

The damage caused by smaller, less powerful, and less smart MANPADS is containable and survivable. However, the same would probably not be true of more advanced missiles such as Stinger RMP and Igla-S. Minimizing hit damage would include some thought devoted to (a) enhancing the physical survivability of aircraft at the manufacturing stage, and (b) providing civilian aircraft pilots with enhanced training on dealing with an aircraft hit. While (a) is an ongoing process that can be directed to some degree by consultations with aircraft manufacturers, (b) again is likely to leave air crew from poorer countries (and thus their passengers) more exposed.

In the broader economic sphere, we feel that Chow et al. (2005)'s predictions of mass panic and paralysis of the air transport system are open to question. There will be extended effects, we agree, on global and national economies but their extent is impossible to predict.

Summary

The main points presented here are constituted from what we consider the most important lessons to be learned from the previous chapters.

Attacks on civilian aircraft:

- The most commonly used MANPADS in attacks against civilian aircraft have been from the Strela family, though others types have also been used.
- Insofar as is known, missiles used in attacks against civilians have either originated from state transfers or thefts from state armories.
- Modern jet aircraft can survive a hit by MANPADS. This is due to a combination of the poor quality of the MANPADS fired (usually a Strela), material structure of the aircraft, and air crew training in responding to emergencies.

MANPADS characteristics:

- MANPADS are very durable and can be functional for decades. Some components are more vulnerable and will deteriorate with time, but so far, this deterioration has defied expectations and old systems may well still function.
- For doctrinal reasons, many militaries are moving away from MANPADS towards the employment of tripod- and vehicle-mounted MANPADS-like systems. This is a benefit, since they are less mobile than MANPADS and more difficult to transfer clandestinely.

Stockpile control:

- In the course of political chaos during regime change, MANPADS stockpiles are extremely vulnerable to leakage. In such cases, normal security procedures do not work, and armories can be looted, with the escape of MANPADS into NSAG and private hands from even the best guarded stockpiles.
- Manufacturers (such as Russia and the United States) face the likelihood that MANPADS provided to NSAGs for political reasons will end up being used against their own civilian aircraft.
- Total world stockpile of MANPADS is probably closer to 500,000 than the 750,000 often cited, even though the major inventories are probably underreported.
- Attempts to recover and destroy MANPADS have reduced world stocks by about 32,000. This is a negligible number representing between less than 10 and less than five percent of world stocks.

Regulation:

- The quality and detail of international regulation of MANPADS has improved in the last decade, leading to hopes that at least some of the threat can be mitigated.
- The strongest basis for MANPADS control is currently the Wassenaar Arrangement's MANPADS Document, supplemented by the OSCE's Best Practice Guide. These two documents serve as the golden standard for MANPADS control, including transfers and stockpile management. Other agreements and arrangements exist, though they rely on the WA standards or are extremely weak, sometimes dissolving into generalities and statements of intent.
- While specific and highly detailed, even the Wassenaar Arrangement suffers from lack of enforcement and oversight.
- Some states that are signatories to one or another of the agreements or other documents, do not uphold the principles in practice, though they profess to do so.
- No state, with the exception of the United States, has legislation that specifically refers to MANPADS, recognizing their uniquely dangerous and difficult nature. Since MANPADS are generally included within normal ammunition legislation, there is little emphasis in law enforcement on these weapons.

Damage control:

- No single countermeasure—technical, diplomatic, or behavioral—is likely to be effective against a MANPADS attack. Layered countermeasures involving focused efforts at interdiction, intelligence, behavioral and technical countermeasures are likely to be the only effective route to controlling MANPADS attacks.
- Due to the constant evolution of MANPADS for military purposes, civilian technical countermeasures must constantly improve and evolve as well.

Policy recommendations

The discussion above also provides openings for some policy recommendations. These derive from the discussion and the data presented, and range over various aspects of MANPADS as a policy problem. Clearly, MANPADS in some form are here to stay. The deployment, and thus production of MANPADS, is part of the inalienable right to self-defense enshrined in the UN Convention and international law. Nevertheless, and without infringing on national sovereignty, there are things the international community, or leading nations in this community, can do to reduce the threat of MANPADS.

Encourage states to specifically and forcefully enact MANPADS legislation

As noted, only one state—the United States—has specific legislation mandating penalties against unauthorized possession or trade in MANPADS. While such legislation in itself would not stop the black market, it would provide law-enforcement authorities with specific tools for the job. It would also serve to draw attention to the specific civilian threat of MANPADS. This type of legislation needs to become universal, through legislative example, by working through multilateral fora such as the OSCE and NATO.

Non-voluntary compliance mechanism for Wassenaar

The Wassenaar Arrangement and the OSCE MANPADS guide provide very specific best practices for MANPADS transfers and stockpiling. The weakness is that these provisions are purely voluntary. Institution, in the first instance, of an oversight mechanism, and in the second, of some form of sanction mechanisms to ensure WA provisions are adhered to, should be considered. Clearly this would need to start well before formal consultation on such a process, in a program of sensitization and lobbying in the member states of the WA. This would require an individual state's leadership and direction, and willingness to be engaged for the long term.

Exchange of real information about legacy MANPADS

As noted, older legacy MANPADS are currently the major threat against civilian aircraft. Yet we do not know, to this day, how many of these have been manufactured, and to whom they have been transferred. This is a recurring problem in all MANPADS studies. Given the need to concentrate largely on weapons produced between twenty and thirty years ago, it seems possible that manufacturing states would be willing to declassify this information, which is no longer militarily sensitive. From the manufacturing/ origin states' point of view, this has a positive and negative side: on the one hand, it would increase and enhance an atmosphere of trust in international relations, on the other it would expose some of these states (viz. the United States, Russia, China) to negative publicity for their past activities. One way to possibly alleviate that is by convening a purely academic meeting for exchange of historical information about MANPADS, with the understanding of full cooperation about historical matters by those countries' governments.

Encourage CREWPADS over MANPADS

It appears that military doctrine is moving away from the use of MANPADS and towards the design, manufacture, and deployment of CREWPADS and self-propelled ADS. This is dictated by changes in military structures, and the move towards more mechanized and mobile forces unrelated to civilian concerns. In due course, it may be possible to encourage states to consider MANPADS, as a weapon type, obsolete in favor of heavier ADS. As it stands, manufacturing states could be encouraged to move doctrinally in that direction, with the aim of shrinking pure MANPADS manufacture.

Continue to provide assistance to poorer countries to secure the approaches to their airports and their aircraft

The likelihood of a MANPADS attack against a well-established, wealthy state's aircraft within its territory appears to be rather low due to the heavy investment in all countermeasure levels discussed above. This is precisely one of the weaknesses in terms of international travel: such heavy investment is not possible for all states. A corollary for that is that more avenues of funding, training, access to technical countermeasures and procedures should be made available to poorer countries. Such a fund would require regular investment, and should not be dedicated solely to one or another solution, given that we know that a layered, comprehensive solution is necessary.

Encourage states manufacturing MANPADS to incorporate coded 'safe gun' mechanisms in all components

Newer models of MANPADS are highly reliant on microcomputers and programming in both missiles and gripstocks. The addition of 'safe gun' technology, which limits use, through codes or keys, to authorized users is a cheap, effective, and relatively simple measure to install. Ensuring that no major component of a MANPADS could be fired by an unauthorized person would greatly reduce the dangers inherent in the 'crumbling regime' effect, which exposes stockpiles to looting, and vastly reduce the attractiveness of stealing MANPADS at a fraction of the cost of manufacturing. Encouraging such a manufacturing change can be engendered through political will, multilateral and bilateral discussions. Ideally, such mechanisms, which are encouraged briefly in the OSCE Best Practice Guide, would become a firm demand within the Wassenaar Arrangement protocols.

Final word

There are three overarching lessons to be learned from the MANPADS phenomenon:

1. No matter the tools employed, it is impossible to ensure to 100 percent that MANPADS will not cause a tragedy.
2. While the struggle between the threat of MANPADS and its abatement is a dynamic between MANPADS and countermeasures ('soft' and technical), it can be reduced overall.
3. No single strategy, device, or practice will restrict the MANPADS threat: Only a combination of those will work, which means a great deal of collaborative and cooperative work at all levels.

Literature cited

African Union. 2012. “Experts’ Meeting on the Situation in the Sahel Region / Follow-Up to the Recommendations of the Joint AU-UN Assessment Mission - Conclusions.” Addis Ababa: African Union, 14–15 March. Available at <http://www.au.int/en/sites/default/files/Conclusion%20ENG.pdf> (accessed 27 November 2012).

Ahram. 2011. “Egypt authorities seize smuggled anti-aircraft weapons.” *Ahram Online,* 25 September. Available at <http://english.ahram.org.eg/NewsContentPrint/1/0/22471/Egypt/0/Egypt-authorities-seize-smuggled-antiaircraft-weap.aspx> (accessed 21 November 2012).

Andrew, Martin. 2009. “PLA Mechanised Infantry Division Air Defence Systems – PLA Point Defence Systems.” *Air Power Australia.* 2009–2012. Available at <http://www.ausairpower.net/APA-PLA-Div-ADS.html> (accessed 26 November 2012).

APEC. See Asia-Pacific Economic Cooperation.

Arasli, Jahangir. 2010. “Unholy Grail: Small Device, Big Hassle – Patterns Of MANPADS Threat Projection By Non-State Actors.” *Eurasia Review,* 28 December. Available at <http://www.eurasiareview.com/28122010-unholy-grail-small-device-big-hassle-patterns-of-manpads-threat-projection-by-non-state-actors> (accessed 09 November 2012).

Arcesolo. 2009. “IGLA- S /SA-24 Grinch- Manpads en Venezuela.” Available at <http://www.youtube.com/watch?v=u_XT0nzvIGQ> (accessed 23 May 2012).

ASB Group. ND. “Thermal batteries - How does it work?” Available at <http://www.asb-group.com/uk/piles-comment.asp> (accessed 12 November 2012).

ASEAN. See Association of Southeast Asian Nations.

Asia-Pacific Economic Cooperation. 2003. “Bangkok Declaration on Partnership for the Future.” Bangkok: Asia-Pacific Economic Cooperation, 21 October. Available at <http://www.apec.org/Meeting-Papers/Leaders-Declarations/2003/~/media/Files/Leaders Declarations/2003/2003_LeadersDeclaration.ashx> (accessed 27 November 2012).

________. 2005. “Busan Declaration - Towards One Community: Meet the Challenge, Make the Change.” Bangkok: Asia-Pacific Economic Cooperation, 18–19 November. Available at <http://www.apec.org/Meeting-Papers/Leaders-Declarations/2005/2005_aelm.aspx> (accessed 27 November 2012).

Association of Southeast Asian Nations. 2006. “Chairman’s Statement of the Thirteenth ASEAN Regional Forum Kuala Lumpur, Malaysia, 28 July.” Jakarta: Association of Southeast Asian Nations. Available at <aseanregionalforum.asean.org/files/library/ARF%20Chairman%27s%20Statements%20and%20Reports/The%20Thirteenth%20ASEAN%20Regional%20Forum,%202005-2006/13th%20ARF%20Chairman%20Statement-Final%20-280706,%2020_00hr.doc> (accessed 27 November 2012).

AU. See African Union.

Australian Government. 2008. “Man-Portable Air Defence Systems (MANPADS): Countering the Terrorist Threat.“ Barton, Department of Foreign Affairs and Trade, June. Available at <http://www.dfat.gov.au/security/MANPADS_countering_terrorist_threat.pdf> (accessed 12 November 2012).

Aviation Safety Network. 2012. “ASN Aviation Safety Database”. Available at <http://aviation-safety.net/database> (accessed 09 November 2012).

Avihai, Hillel. 2008. “MANPADS Countermeasure: Sky Security vs. Ground Security.” Herzliya, Israel: International Institute for Counter-Terrorism, 21 January. Available at <http://www.ict.org.il/Articles/tabid/66/Articlsid/272/currentpage/3/Default.aspx> (accessed 28 November 2012).

Avvocato Militare. 2012. “NATO sponsors project to help reduce terrorism risk in Mauritania.” *Avvocato Militare,* 15 September. Available at <http://www.avvocatomilitare.it/sentenza.php?id=2748> (accessed 26 November 2012).

Bartak, John R. 2005. “Mitigating the MANPADS Threat: International Agency, U.S., and Russian Efforts.” *Thesis.* Monterey, California: Naval Postgraduate School. Available at <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA432299> (accessed 26 November 2012).

Basar, Eray. 2012. “Report Update: Unsecured Libyan Weapons – Regional Impact and Possible Threats.”

Civil Military Fusion Centre, November. Available at <https://www.cimic web.org/cmo/medbasin/Holder/Documents/r022%20CFC%20Monthly%20Thematic%20Report%20%28Update%29%20%2802-NOV-12%29.pdf> (accessed 21 November 2012).

Batacchi, Pietro. 2012. "Tuaregs Seized Regional Zeitgeist in Successful Coup." *Defense News.* Available at <http://www.defensenews.com/article/20120422/DEFFEAT05/304220006/Tuaregs-Seized-Regional-Zeitgeist-Successful-Coup?odyssey=mod|newswell|text|FRONTPAGE|s> (accessed 21 November 2012).

BBC. 2002. "The Threat from Portable Missiles". *BBC News, World Edition, Africa.* Available at <http://news.bbc.co.uk/2/hi/africa/2527645.stm> (accessed 08 November 2012).

Berman, Eric G., Matt Schroeder and Jonah Leff. 2011. "Man-Portable Air Defence Systems (MANPADS)." *Research Notes,* No. 1. Geneva: Small Arms Survey. Available at <http://www.smallarmssurvey.org/fileadmin/docs/H-Research_Notes/SAS-Research-Note-1.pdf> (accessed 09 November 2012).

Benari, Elad. 2011. "Gaza Terror Groups Acquire Weapons from Libya." *Arutz Sheva,* 30 August. Availableat<http://www.israelnationalnews.com/News/News.aspx/147344#.UIFPfYbnfcs%3EElad%20Benari> (accessed 22 November 2012).

Blasko, Dennis J. 2005. "Chinese Army Modernization: An Overview." *Military Review,* Vol. 85, No. 5, pp. 68–74.

Bolkcom, Christopher, Bartholomew Elias and Andrew Feickert. 2003. "MANPADs Threat to Commercial Aviation." Washington, DC/ Paris/ Brussels: Congressional Research Service/ Institut français des relations internationales. Available at <http://www.ifri.org/files/CFE/CFEbolkcom.pdf> (accessed 28 November 2012).

Bolkcom, Christopher and Bartholomew Elias. 2006. "Homeland Security: Protecting Airliners from Terrorist Missiles." *CRS Report for Congress.* Washington, DC: Congressional Research Service, updated 16 February. Available at <http://digital.library.unt.edu/ark:/67531/metacrs8580/m1/1/high_res_d/RL31741_2006Feb16.pdf> (accessed: 28 November 2012).

Bouckaert, Peter. 2011. "Libya: unsecured explosive weapons." Feature. New York: Human Rights Watch. Available at <http:/www.hrw.org/features/libya-unsecured-explosive-weapons> (accessed 21 November 2012).

Brooks, Carter (Ben), Gregory J. Czarnecki, Christine M. Belcastro, Celeste M. Belcastro and J. Michael Heard. 2005. "Large Aircraft Survivability Initiative (LASI): Survivability Against Man Portable Air Defense Systems." Aircraft Survivability. Arlington, VA: Joint Aircraft Survivability Program Office, pp. 6–7.

Bruno, Michael. 2006. "DHS Seeks Emerging Anti-MANPADS Technologies." *Aviation Daily,* Vol. 364, No. 18.

Buongiorno, Matt. 2009. "MANPADS Transfers Reported to the UN Arms Register", 2 November. Available at <http://www.fas.org/programs/ssp/asmp/issueareas/manpads/UN_Register_MANPADS_Data.html> (accessed 20.12.2012).

Burdick, Eddie. 2010. *Three Days in the Hermit Kingdom: An American Visits North Korea.* Jefferson, North Carolina: McFarland.

Cagle, Mary T. 1974. "History of the Redeye Weapon System." *Historical Monograph, Project Number AMC 78M.* Alabama: Historical Division, US Army Missile Command, Redstone Arsenal. Available at <http://www.fas.org/asmp/campaigns/MANPADS/2005/redeye.pdf> (accessed 12 November 2012).

Case, Russell L., Jr. and Peter H. Wolff. 2006. "Commercial – Aircraft Protection System" In Edward M. Carapezza (ed.). *Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security and Homeland Defense* III. Vol. 5403, Bellingham, Washington, USA: SPIE, pp. 515–21.

Cherry, Mark C., Stuart C. Kramer and Joel J. Hagan. 1996. "A comparison of guided and unguided anti-missile kinetic kill countermeasures." Proceedings of the IEEE 1996 National Aerospace and Electronics Conference (NAECON). 20–23 May. Vol. 2, pp. 547–52.

Chivers, C. J. 2011a. "Antiaircraft Missiles on the Loose in Libya." *New York Times.* 14 July. Available at <http://www.nytimes.com/2011/07/15/world/africa/15libya.html?pagewanted=all&_r=0 > (accessed 6 December 2012).

________. 2011b. “Reading the Refuse: Counting Qaddafi’s Heat –Seeking Missiles, and Tracking Them Back to Their Sources.” *New York Times At War: Notes from the Front Lines,* 26 July. Available at <http://atwar.blogs.nytimes.com/2011/07/26/reading-the-refuse-counting-col-qaddafis-heat-seeking-missiles-and-tracking-them-back-to-their-sources/> (accessed 19 November 2012).

________. 2012. “Confronting a False Meme: Libya’s Deadly ‘Stinger Equivalent’.” *New York Times At War: Notes from the Front Lines,* 24 May. Available at <http://atwar.blogs.nytimes.com/2012/05/24/confronting-a-false-meme-libyas-deadly-stinger-equivalents/> (accessed 22 November 2012).

Choi, Jin Tai. 2010. “Threats of MANPADS and Its Counter-Measures” *International Journal of Contents,* Vol. 6, No. 3. pp. 89–96.

Chow, James, James Chiesa, Paul Dreyer, Mel Eisman, Theodore W. Karasik, Joel Kvitky, Sherrill Lingel, Davis Ochmanek and Shirley Chad. 2005. “Protecting Commercial Aviation Against the Shoulder-Fired Missile Threat.” *Occasional Paper,* No. 106. Santa Monica: RAND. Available at <http://www.rand.org/pubs/occasiona_papers/2005/RAND_OP106.pdf> (accessed 12 November 2012).

CIA. 2012. “Airports.” *The World Factbook.* Available at <https://www.cia.gov/library/publications/the-world-factbook/fields/2053.html> (accessed: 28 November 2012).

Clinton, Hillary. 2008. “Finding a way forward on Ukraine NATO PFP trust fund project.” *Cable 08STATE130187.* Available at <http://wikileaks.org/cable/2008/12/08STATE130187.html> (accessed 17 December 2012).

________. 2009a. “Russia’s Anticipated Transfer of Igla-S (SA-24) MANPADS to Venezuela.” *Cable 09STATE14070.* Available at <http://www.cablegatesearch.net/cable.php?id=09STATE14070> (accessed 27 November 2012).

________. 2009b. “Ukraine: reporting on the February 24-25, 2009 [meeting].” *Cable 09STATE40237.* Available at <http://wikileaks.org/cable/2009/04/09STATE40237.html> (accessed 15 November 2012).

Comando Conjunto De Las FF.AA. 2007. Presentation of Ecuadorian Armed Forces at Stockpile and Surplus Workshop, San Juan, Costa Rica, March 2007. In possession of authors.

Congressional Record. 1987. *Stinger Sting.* 31.03.1987. Available at <http://www.fas.org/programs/ssp/asmp/issueareas/manpads/Congressional_Record_31march1987.pdf> (accessed 22 November 2012).

Cooper, Thomas with Esteban Rivera. 2003. “Peru vs. Ecuador: Alto-Cenepa War, 1995.” ACIG Central and Latin America Database. <http://www.acig.org/artman/publish/article_164.shtml> (accessed 15 August 2012).

Cordovez, Diego and Selig S. Harrison. 1995. *Out of Afghanistan - The Inside Story of the Soviet Withdrawal.* New York: Oxford University Press.

Cukali, Besnik. 2003. “Symbolic Destruction of MANPADS Stockpile.” *NATO Stabilisation Force.* 08 December. Available at <http://www.nato.int/sfor/indexinf/articles/031205b/t031205b.htm> (accessed 22 November 2012).

Czarnecki, Gregory J., Robert Yelverton and Carter (Ben) Brooks. 2005. “Large Aircraft Vulnerability to Man-Portable Air Defense Systems (MANPADS).” *Aircraft Survivability,* Summer, pp. 10, 17. Available at <http://jaspo.csd.disa.mil/images/archive/pdf/2005_summer.pdf> (accessed 08 November 2012).

Czarnecki, Gregory J., Stan Loumiller, John Valek, Tim Grose and John Haas. 2011a. “MANPADS Threat Model Development – Characterization of Static and Dynamic Blast, Fragmentation, and Missile Body Debris.” *Aircraft Survivability,* Fall, pp. 6–8. Available at <http://jaspo.csd.disa.mil/images/archive/pdf/2011_fall.pdf> (accessed 12 November 2012).

Czarnecki, Gregory J., Joe Manchor, Gautam Shah and John Haas. 2011b. “Large Engine Vulnerability to MANPADS,” *Aircraft Survivability,* Fall 2011, pp. 9–11. Available at <http://jaspo.csd.disa.mil/images/archive/pdf/2011_fall.pdf> (accessed 12 November 2012).

Davidson, Michael W. 2003. "Thermal batteries." *Molecular Expressions: Electricity and Magnetism.* 28 January. Available at <http://micro.magnet.fsu.edu/electromag/electricity/batteries/thermal.html> (accessed 12 November 2012).

Davis, Ian. 2002. *The Regulation of Arms and Dual-Use Exports: Germany, Sweden and the UK*. Oxford: Oxford University Press.

Defense Update. 2007. "Igla-S, Igla-1 – SA-16/18." *Defense Update*, 23 July. Available at <http://defense-update.com/20070723_sa-8.html> (accessed 14 November 2012).

Donovan, Kevin F., 1996. "The Economics of Proliferation in the People's Republic of China." *Research Report*. Maxwell, Alabama: Air War College/ Air University. Available at: <http://www.fas.org/nuke/guide/china/doctrine/donovan_kf.pdf> (accessed 8 January 2013).

Doughty, Daniel H., Paul C. Butler, Rudolph G. Jungst, and E. Peter Roth. 2002. "Lithium battery thermal models." *Journal of Power Sources,* Vol. 110, No. 2, pp. 357–63.

Duffy, Jonathan. 2003. "Could Your Airline Fend off a Missile?" *BBC News Online Magazine,* 19 August. Available at <http://news.bbc.co.uk/2/hi/uk_news/magazine/3159895.stm> (accessed 13 November 2012).

Dyer, Walter R. 2004. "Sample pages from Modern missile analysis: Guidance, control, seekers, and technology." Washington, DC: Applied Technology Institute. Available at <http://www.aticourses.com/sampler/Modern_Missile_Analysis.pdf> (accessed 14 November 2012).

Ellison, J. R. and S. J. Ojala. 1969. *Flexible exit cone nozzle demonstration firing results.* Edwards, CA: Air Force Propulsion Laboratory.

Embassy Budapest. 2006. "MANPADS Cooperation Near to Conclusion." Recently *at the Embassy.* Embassy of the United States of America Budapest Newsletter. Available at <http://hungary.usembassy.gov/media/pdfs/newsletter_04_27_2006.pdf> (accessed 20 December 2012).

Embassy Moscow. 2004. "Follow-up On U.S.-Russia Manpads Cooperation." Available at <http://wikileaks.org/cable/2004/12/04MOSCOW15782.html> (accessed 1 November 2012).

Erwin, Sandra. 2003. "Man-Portable Missiles Imperil Both Military, Civilian Aircraft." *National Defense Magazine,* August. Also available at <http://www.nationaldefensemagazine.org/archive/2003/August/Pages/Man-Portable3804.aspx> (accessed 09 November 2012).

Fiszer, Michel and Jerzy Gruszczynski. 2002. "On Arrows and Needles." *Journal of Electronic Defense,* Vol. 25, No. 12, pp. 46–52.

Freedman, Lawrence. 2005. *The official history of the Falklands campaign. Volume II: War and diplomacy.* Abingdon, New York: Routledge.

Frieden, David R. (ed.). 1985. *Principles of Naval Weapons Systems.* Annapolis: Naval Institute Press.

Forero, Juan. 2010. "Venezuela acquired 1,800 Russian antiaircraft missiles in '09." *Washington Post.* 12 December. Available at <http://www.washingtonpost.com/wp-dyn/content/article/2010/12/11/AR2010121103148.html> (accessed 10 December 2012).

G8. 2003. "Enhance Transport Security and Control of Man-Portable Air Defence Systems (MANPADS) – A G8 Action Plan." *G8 Evian Summit 2003.* Available at <http://www.g8.fr/evian/extras/502.pdf> (accessed 27 November 2012).

________. 2004. "G8 Secure and Facilitated International Travel Initiative" *G8 Sea Island Summit 2004*. Available at <http://www.g8.utoronto.ca/summit/2004seaisland/travel.html> (accessed 27 November 2012).

Gabor, Laszlo Zord. 2011. "Hungary's last man-portable air defence missile fired during drill-daily." BBC Monitoring International Reports. (23 April): Excerpt from report by Magyar Nemzet on 22 April. Available at <http://www.accessmylibrary.com/article-1G1-254629401/hungary-last-man-portable.html> (accessed 17 December 2012).

Gander, Ian. 2011. "MANPADS - Man-portable air-defense systems." Defense Threat Information Group. Available at <http://www.dtig.org/docs/MANPADS.pdf> (accessed 13 November 2012).

Gertz, Bill. 2007. "Iran arms Iraqi insurgents." *Washington Times,* 12 February. Available at <http://www.homelandsecurityus.com/archives/1626> (accessed 15 August 2012).

Global Security. 2011. “Vigilant Eagle.” Alexandria, VA: Global Security. Available at <http://www.globalsecurity.org/security/systems/vigilant-eagle.htm> (accessed 28 November 2012).

Grant, S and E. Richardson. 2007. “Counter-MANPADS System Headed for Airports.” *Journal of Electronic Defense,* Vol. 30, No. 8, August, pp. 18–19.

Greenlee, David N. 2006. “MANPADS: Ex-President Rodriguez on the defensive.” *WikiLeaks,* 21 August. Available at <http://wikileaks.vice-presidencia.gob.bo/MANPADS-EX-PRESIDENT-RODRIGUEZ-ON> (accessed 26 November 2012).

Guardian. 2010. “US embassy cables: US considers selling arms to Uganda.” *The US embassy cables: The documents, 06 December 2007.* Available at <http://www.guardian.co.uk/world/us-embassy-cables-documents/133098> (accessed 26 November 2012).

Guhl, J.M. 2012. “Countering MANPADS” *Avionics Today,* 01 February. Available at <http://www.aviationtoday.com/av/military/Countering-MANPADS_75571.html#.ULY-zNcuSbw> (accessed 28 November 2012).

Guidotti, Ronald A. and Pattrick Masset. 2006. “Thermally activated (’thermal’) battery technology. Part I: an overview.” *Journal of Power Sources,* Vol. 161, No. 2, pp. 1443–49.

Hanlon, Mike. 2010. “Personalised, electronic handgun headed for commercialization.” gizmag. Available at <http://www.*gizmag*.com/personalised-electronic-handgun-headed-for-commercialisation/2376/> (accessed 28 November 2012).

Harel, Amos and Avi Issacharoff. 2011. “Hamas boosting anti-aircraft arsenal with looted Libyan missiles.” *Haaretz,* 27 October. Available at <http://www.haaretz.com/print-edition/news/hamas-boosting-anti-aircraft-arsenal-with-looted-libyan-missiles-1.392186> (accessed 21 November 2012).

Herald Reporters. 1978. “The Hunyani Disaster – A Compilation of Newspaper Reports.” Available at <http://www.rhodesia.nl/viscount.htm> (accessed 09 November 2012).

Herz, Monmica. 2002. *Ecuador vs. Peru: Peacemaking amid rivalry.* Boulder, CO: Lynne Rienne.

Hillson, Franklin J. 1989. “Barrage balloons for low-level air defense.” *Airpower Journal,* Vol. 3, No. 2. Available at <http://www.airpower.maxwell.af.mil/airchronicles/apj/apj89/hillson.html> (accessed 12 November 2012).

Holtom, Paul. 2007. “Ukrainian arms supplies to sub-Saharan Africa.” *Sipri Occasional Papers.* Stockholm: SIPRI. Available at <http://www.scribd.com/doc/52920253/Ukrainian-arms-supplies-to-sub-Saharan-Africa> (accessed 17 December 2012).

Hughes, Chris. 2012. “CIA spies ‘smuggle 14 Stinger missiles into Syria so rebels can take out regime warplanes.’” *Mirror,* 18 August. Available at <http://www.mirror.co.uk/news/world-news/cia-spies-smuggle-14-stinger-1266487> (accessed 22 November 2012).

________. 2007. “MANPADS - What are they and how do they work?” Presentation at the one-day OAS conference entitled “Effective Strategies to Migitate the Threat Posed by the use of Man-portable Air Defense Systems (MANPADS) by non-State actors.” 8 March. Available at <http://www.fas.org/asmp/campaigns/MANPADS/2007/Hughes8March07.wmv> (accessed 21 November 2012).

Hughes, David. 2004. “Protection: Israeli Style.” *Aviation Week & Space Technology.* Vol. 160, No. 20, pp. 41–42.

IATA. See International Air Transport Association.

ICAO. See International Civil Aviation Organization.

IFALPA. See International Federation of Air Line Pilots’ Associations.

IISS. See International Institute for Strategic Studies.

In From the Cold. 2011. “MANPADS for the NYPD?” 25 September. Available at <http://formerspook.blogspot.de/2011/09/manpads-for-nypd.html> (accessed 26 November 2012).

International Air Transport Association. 2012. *Annual Review 2012.* Beijing: IATA, June. Available at <http://www.iata.org/about/Documents/annual-review-2012.pdf> (accessed 5 December 2012).

International Civil Aviation Organization. 2007. “Threat to Civil Aviation posed by Man-Portable Air Defence Systems (MANPADS)”. Montreal: ICAO, 14 September. Available at <http://legacy.icao.int/icao/en/assembl/a36/wp/wp026add_en.pdf> (accessed 21 November 2012).

International Federation of Air Line Pilots’ Associations. 2006. “MANPADS Threat Assessment.” *Security Briefing Leaflet* 07SECBL01, December. Washington, DC: ALPA. Available at <http://www.ifalpa.org/downloads/Level1/Briefing%20Leaflets/Security/07SECBL01-%20MANPAD%20Thret%20Assesment.pdf> (accessed 29 August 2012).

International Institute for Strategic Studies. 2012. *Military Balance 2012.* London: Routledge.

International Shipping News. 2010. “The Somali Pirates told the truth.” 09 December. Available at <http://internationalshippingnews.blogspot.de/2010/12/somali-pirates-told-truth.html> (accessed 15 November 2012).

________. 2011. “Update - Crew of Leopard Taken by Pirates.” 13 January. Available at <http://internationalshippingnews.blogspot.de/2011/01/update-crew-of-leopard-taken-by-pirates.html> (accessed 15 November 2012).

Isby, David C. 2001. “Russia sells Igla to North Korea and India.” *Jane’s Missiles and Rockets.* Available at <http://articles.janes.com/articles/Janes-Missiles-And-Rockets-2001/Russia-sells-Igla-to-North-Korea-and-India.html> (accessed 20 December 2012).

Isensen, Nancy and Daryl Lindsey. 2002. “Kenya Rocket Attack: Is Europe Next?” *Deutsche Welle News.* Available at <http://www.dw.de/dw/article/0,,#688486,00.html> (accessed 08 November 2012).

Jackman, James, Mark Richardson, Brian Butters, Roy Walmsley, Nic Millwood, Peter Yuen and David James. 2009. “Analysis of first generation MANPAD attacks on fast jets.” In David H. Titterton and Mark A. Richardson (eds.). *Technologies for Optical Countermeasures VI Vol. 7483,* Bellingham, Washington, USA: SPIE, pp. 74830I-1–74830I-12.

Jackman, James, Mark Richardson, Peter Yuen, David James, Brian Butters, Roy Walmsley and Nic Millwood. 2010. “Effects of payloads size on pre-emptive flare countermeasure against Man-Portable Air-Defence (MANPAD) system.” In David H. Titterton and Mark A. Richardson (eds.). *Technologies for Optical Countermeasures VII Vol. 7836,* Bellingham, Washington, USA: SPIE, pp. 78360M-1–7836M-8.

Jane’s. 2011a. “Starstreak” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2011b. “Strela-2” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2011c. “Bolide” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2011d. “Strela-2M” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2011e. “Strela-2M/A” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2011f. “FN-6 (HY-6)” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2011g. “Mistral 1” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2011h. “Sakr Eye” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2011i. “HN-5” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012a. “QW-3” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012b. “QW-1” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012c. “Igla” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012d. “CA-94M” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012e. “Starstreak I” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012f. “Igla-1” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012g. “FIM-92 Stinger” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012h. “RBS 70” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012i. “Javelin” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012j. “Starburst” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012k. “FN-16” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012l. “Chiron (Singung)” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012m. “Igla-S” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012n. “Strela-3” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012o. “QW-2” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012p. “QW-4” Land Warfare Platforms: Artillery & Air Defence. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012q. “QW-11” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012r. “QW-18” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012s. “Mistral 2” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 29 November 2012).

________. 2012t. “Igla-1E” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 13 December 2012).

________. 2012u. “North Korean man-portable surface-to-air missile systems” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 13 December 2012).

________. 2012v. “Misagh-1” Land Warfare Platforms: Artillery & Air Defence. Available via <https://janes.ihs.com> (accessed 13 December 2012).

________. 2012w. “Misagh-2” *Land Warfare Platforms: Artillery & Air Defence*. Available via <https://janes.ihs.com> (accessed 13 December 2012).

Joshi, Saurabh. 2011a. “MBDA pitches Mistral for Indian VSHORAD tender.” *StratPost,* 09 December. Available at <http://www.stratpost.com/mbda-pitches-mistral-for-indian-vshorad-tender> (accessed 12 November 2012).

________. 2011b. “Saab offers India ‘unjammable’ RBS 70 NG VSHORAD.” *StratPost,* 27 September. Available at <http://www.stratpost.com/saab-offers-india-unjammable-rbs-70-ng-vshorad> (accessed 21 November 2012).

Kaiser, Stefan A. 2010. “Aviation Security: Technical and Regulatory Measures against MANPADS.” *Air and Space Law,* Vol. 35, No. 1, pp.45–58.

Karon, Tony. 2012. “Is Syria Facing a Yugoslavia-Style Breakup?” *Time World,* 19 July. Available at <http://world.time.com/2012/07/19/is-syria-facing-a-yugoslavia-style-breakup/> (accessed 21 November 2012).

Karp, Aaron. 2009. "Surplus Arms in South America: A Survey." *Working Paper*. Geneva: Small Arms Survey, August. Available at <http://www.smallarmssurvey.org/fileadmin/docs/F-Working-papers/SAS-WP7-Surplus-Arms-in-South-America.pdf> (accessed 19 November 2012).

Kirkham, Elizabeth and Nneka Okechukwu. 2010. *Controlling the transfer of Man-Portable Air Defence Systems: A guide to best practice*. London. Saferworld.

Knight, Helen. 2004. "Anti-Missile Technology: Calling the shots." *Engineer,* 24. September, pp. 26–29. Available at <http://www.theengineer.co.uk/in-depth/calling-the-shots/266979.article> (accessed 28 November 2012).

Knowles, J. 2007. "DHS Considers New Counter-MANPADS Effort." *Journal of Electronic Defense,* Vol. 30, No. 4, April, p. 24.

Kopp, Carlo. 1982. "Heat-seeking missile guidance." *Australian Aviation*. March. Available at <http://www.ausairpower.net/TE-IR-Guidance.html> (accessed 15 November 2012).

________. 1989. "Man portable surface-air missiles." *Australian Aviation*. July. Available at <http://www.ausairpower.net/mpsam.html> (accessed 20 November 2012).

________. 2003. "Man Portable Missiles vs. Airliners." *Australian Aviation*. December, pp. 31–35.

Krajefsky, Thomas. 2004. "President Saleh to A/S Bloomfield 'No New MANPADS'." Available at <http://files.vpro.nl/wikileaks/cable/2004/09/04SANAA2346.html> (accessed 19 December 2012).

Kren, Lawrence. 2006. "Targeted beam protects airliners from shoulder-fired missiles." *Machine Design,* Vol. 78, No. 23.

Krol, George Alber. 2005. "Belarus Reneges on SA/LW Destruction; De-mining on Track." *WikiLeaks cable 05MINSK1359*. Available at <http://wikileaks.org/cable/2005/11/05MINSK1359.html> (last accessed: 26 November 2012).

Kuhn, David A. 2003. "Mombasa Attack Highlights Increasing MANPADS Threat." *Jane's Intelligence Review*. February, pp. 26–31.

Liams, Kevin. 2006. "The MANPAD Threat to Civilian Airliners." US Army War College Strategy Research Project. Available at <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA449391> (accessed 28 November 2012).

Lindsell-Stewart, Gavin. 1978. "Three Describe a Night of Terror". *The Hunyani Disaster – A Compilation of Newspaper Reports*. Available at <http://www.rhodesia.nl/viscount.htm> (accessed 09 November 2012)

Litovkin, Viktor. 2005. "Strelets is not a Terrorist Weapon." *Ria Novosti*. 17 February 2005. Available at <http://en.rian.ru/analysis/20050217/39702393.html> (accessed 13 November 2012).

Lyons, John, Duncan Long and Richard Chait. 2006. "Critical Technology Events in the Development of the Stinger and Javelin Missile Systems-Project *Hindsight* Revisited." *Defense & Technology Papers* No. 33. Washington, DC: Center for Technology and National Security Policy; National Defense University, July. Available at <http://www.ndu.edu/CTNSP/docUploaded/DTP%2033%20Missiles.pdf> (accessed 12 November 2012).

Ma'an. 2012. "Egypt army says anti-aircraft missiles seized in Sinai." *Ma'an News Agency*. 11 February. Available at <http://www.maannews.net/eng/ViewDetails.aspx?ID=459519>, (accessed 21 November 2012).

Macfadzean, Robert. 1992. *Surface-Based Air Defense System Analysis*. Norwood, MA: Artech House.

MAG. See Mines Advisory Group.

Malglaive, Etienne de. ND. "_MG_1222X.jpg - Libyan rebel watch Sa-24 anti aircraft missiles on the back of a pick up truck, inside Bab Al Aziziya compound the day after it was stormed from Gadhafi's forces." Available at <http://malglaive.photoshelter.com/image/I0000YZgvyVBirRQ> (accessed 17 December 2012).

Maltese, Dominique, Jean-Thierry Robineau Jaques, Julien Aragones and Christophe Sailliot. 2006. "Countering MANPADS: Study of New Concepts and Applications." In Theodore T. Saito and Daniel Lehrfeld (eds.). *Optics and Photonics in Global Homeland Security II Vol. 6203*. Bellingham, Washington, USA: SPIE, pp. 62030G-1–62030G-12.

Mariani, Bernardo. 2007. “Small Arms and Light Weapons Transfer Controls in the CIS Region.” *Towards Global Standards – Regional Experience In Small Arms Transfer Controls.* Edited Papers from an International Seminar. Waterloo, Canada: Project Ploughshares, 08 February, pp. 38–54. Available at <http://www.saferworld.org.uk/downloads/pubdocs/TowardsGlobalStandards.pdf> (accessed 27 November 2012.).

Marrouch, Rima. 2012. “Syrian Rebels Gaining Ground Against Assad’s Air Power.” *Los Angeles Times.* 11 December. Available at <http://articles.latimes.com/2012/dec/11/world/la-fg-syria-rocket-man-20121212 > (accessed 19 December 2012).

Martynyuk, Anton and F. David Diaz. 2009. “Cyprus confronts its MANPADS menace.” *OSCE Magazine.* December, pp. 27–30.

Matthews, Neelam. 2012. “Syrian rebels have MANPADS?” 17 August. Available at <http://aerospacediary.blogspot.de/2012/08/syrian-rebels-have-manpads.html> (accessed 25 August 2012).

McKenna, Ted. 2006. “’Get Real,’ Say Airline Reps About MANPADS.” *Journal of Electronic Defense,* Vol. 29, No. 6, June, pp. 18–20.

McLeary, Paul. 2011. “State Updates Progress On Manpads Threat.” *Aviation Daily Vol. 385, No. 23.*

McMichael, Scott R. 1991. *Stumbling Bear - Soviet Military Performance in Afghanistan,* London: Brassey’s.

McMichael, William. 2010. “Drug, arms trafficking big SouthCom concerns.” *Army Times,* 28 April. [Cited in “Global News: UN Arms Register: Venezuela was the largest importer of MANPADS in 2009” Missile Watch 3(3): 3–5 November 2010. <http://www.fas.org/programs/ssp/asmp/publications/ASMP_Publications_2010/Missile_Watch_Vol3_Issue3.pdf> (accessed 23 November 2012).

Ministry of Foreign Affairs of the Russian Federation. 2003. “Elements for Export Controls of Man-Portable Air Defence Systems (MANPADS).” Available at <http://www.mid.ru/bdomp/ns-dvbr.nsf/416a07318ecf41dd432569ea00361456/4bf4810b528736bbc3256e28004d078b!OpenDocument> (accessed 28 November 2012).

Ministry of Defence, Government of the United Kingdom. 2012. “MOD Personnel Help Secure Libyan Portable Air Defence Systems.” *Defence Talk.* 16 April. Available at <http://www.defencetalk.com/mod-personnel-help-secure-libyan-portable-air-defence-systems-41639/> (accessed 21 November 2012).

Mines Advisory Group. 2008. “Burundi: 30 MANPADS destroyed.” 13 June. Available at <http://www.magamerica.org/burundi-30-manpads-destroyed> (accessed 22.11.2012).

Moss, Trefor. 2009. “Sri Lankan advance uncovers LTTE cache of Strela-3s.” *Jane’s Defence Weekly.* 17 April. Available via <https://janes.ihs.com> (accessed 22.11.2012).

Munter, Cameron. 2008. “Engaging Serbia on MANPADS Sale and Destruction.” *LeakOverflow cable* 07BELGRADE1659. Available at <http://www.leakoverflow.com/questions/486029/08belgrade54-c-engaging-serbia-on-manpads-sale-and-destruction> (accessed 26 November 2012).

Mutzinzi, Jean, Jean Damascène Bizimana, Alice Rugira, Judith Mbabazi, Augustin Mukama, Peter Mugenzi and Jean-Baptiste Mvano. 2009. “Investigation Report - Essential Elements Contained in the Investigation Report”. *Independent Committee of Experts Investigating the Fatal Crash on 06 April 1994 of the Falcon 50 Plane With Registration Number 9XR-NN.* Available at <http://mutsinzireport.com/wp-content/uploads/2010/01/SUMMARY-ENGLISH.pdf> (accessed 09 November 2012).

N.A. 2007. “QW-3 surface-to-air missile.” 30 July. Sinodefence.com. Available at <http://www.sinodefence.com/army/surfacetoairmissile/qw3.asp> (accessed 12 November 2012).

N.A. 2008a. “Belarus completes destruction of MANPADS in cooperation with OSCE.” Naviny. BY/PDA 08.12.2008. <http://naviny.by/pda/material/?type=news&id=302757> (accessed: 26 November 2012).

N.A. 2008b. “GlobalSecurity.org: Belarus scraps obsolete Strela-2M MANPADS.” <http://www.allvoices.com/news/1970964/s/24872769-globalsecurity-org-belarus-scraps--obsolete-strela-2m-manpads> (accessed 28.09.2012).

NA. 2009. “Indonesia buys new SHORADS.” 30 May. Defense Studies. Available at <http://defense-studies.blogspot.de/2009/05/indonesia-buys-new-shorads_30.html> (accessed 12 November 2012).

NA. 2012. “Stinger US-made Anti-Aircraft Missile Specs and Performance.” (In Arabic). Available at <http://www.facebook.com/ahrrarsyria/posts/460531543985363> (accessed 19.12.2012).

NA. ND. “Mistral short-range air-defence missile system, France.” *Army Technology*. Available at <http://www.army-technology.com/projects/mistral-missile/> (accessed 12 November 2012).

NA. ND. “IGLA- S /SA-24 Grinch- Manpads en Venezuela.” Available at <http://www.youtube.com/watch?v=u_XT0nzvIGQ>. Accessed 8 August 2012.

NAMSA. See NATO Maintenance and Supply Agency.

National Policing Improvement Agency. 2011. *Reference Handbook - Guidance on Policing at Airports.* NPA, Scotland. Available at <http://www.acpo.police.uk/documents/uniformed/2011/20110214%20UOBA%20Reference%20Handbook_Guidance%20on%20Policing%20at%20Airports_FINAL_Feb2011.pdf> (accessed 28 November 2012).

NATO. See North Atlantic Treaty Organization.

North Atlantic Treaty Organization. 2011. “Status of Trust Fund Projects - 04 February 2011.” Available at <http://www.nato.int/nato_static/assets/pdf/pdf_2011_02/20110630_20110204-TF_status_report_0402.pdf> (accessed 20 December 2012).

________. 2004. “NATO Efforts to Counter the Threat of MANPADS.” *Follow Up Meeting to the UN-CTC Special Meeting on 6 March 2003.* Available at <http://www.osce.org/atu/24961> (accessed 27 November 2012).

North Atlantic Treaty Organization. Maintenance and Supply Agency. 2012. “NATO/PfP Trust Fund Project in Tajikistan.” *Fact Sheet 31 January*. Available at <http://www.namsa.nato.int/news/pdf/trust-fund-tajikistan-factsheet.pdf> (accessed 26 November 2012).

Nerguizian, Aram and Anthony H. Cordesman. 2011. “Instability in Syria: Assessing the Risks of Military Intervention.” Working Draft. 13 December. Washington, DC: Center for Strategic and International Studies. Available at <http://csis.org/files/publication/111213_SyriaMilitaryIntervention.pdf>(accessed 19 November 2012).

NPIA. See National Policing Improvement Agency.

OAS. See Organization of American States.

Ochsenbein, Adrian. 2008. “Das Boden-Luft Lenkwaffensystem SA-18 GROUSE & SA-24 GRINCH.” Defense Threat Information Group. Available at <http://www.dtig.org/docs/SA-18.pdf> (accessed 12 November 2012).

Office of Weapons Removal and Abatement. Bureau of Political-Military Affairs. US Department of State. 2007. Small Arms/Light Weapons. Presentation, October. Available at <http://www.fas.org/programs/ssp/asmp/issueareas/manpads/1_adams_small_arms_light_weapons.pdf> (accessed 20 December 2012).

Okpara, Uche and Vicki M. Bier. 2008. “Securing Passenger Aircraft from the Threat of Man-Portable Air Defense Systems (MANPADS).” *Create Published Articles & Papers,* Paper 126. Available at <http://research.create.usc.edu/published_papers/126> (accessed 28 November 2012).

Organization for Security and Co-operation in Europe. 2003. “Man-Portable Air Defence Systems.” *Decision No. 7/03. FSC.DEC/7/03. 23 July*. Available at <http://www.osce.org/fsc/43128> (accessed 27 November 2012).

________. 2004. “Principles for Export Controls of Man-Portable Air Defence Systems (MANPADS)” *Decision No. 3/04. FSC.DEC/3/04. 26 May.* Available at <http://www.osce.org/fsc/32593> (accessed 27 November 2012).

________. 2006. “Best Practice Guide on National Procedures for Stockpile Management and Security – Annex C: Man-Portable Air Defence Systems (MANPADS).” *FSC.DEL/33/06. 03 March.* pp. 17a–17h. Available at <http://scm.oas.org/pdfs/2007/cp17707E.pdfs.

________. 2008. “Updating the OSCE Principles for Export Controls of Man-Portable Air Defence Systems.” *Decision No. 5/08. FSC.DEC/5/08.* 26 May. Available at <http://www.osce.org/fsc/32082> (accessed 27 November 2012).

Organization of American States. 2005. "Denying MANPADS to Terrorists: Control and Security of Man-Portable Air Defense Systems (MANPADS)." *AG/RES. 2145*. 07 June. Available at <https://www.unodc.org/tldb/pdf/CICTE/CICTE_AG-RES_2145-05_ENG.pdf> (accessed 27 November 2012).

________. 2006. "Cooperation on Some Matters of Security in the Hemisphere." *AG/RES. 2246*. pp. 320–22. Available at <http://www.oas.org/en/sla/docs/AG03341E09.pdf> pp. 320–322 (accessed 27 November 2012).

O'Sullivan, Terry. 2005. "External Terrorist Threats to Civilian Airliners: A Summary Risk Analysis of MANPADS, other Ballistic Weapons Risk, Future Threats, and Possible Countermeasures Policies." *Report 05-009*. Los Angeles, CA: Center for Risk and Economic Analysis of Terrorism Events (CREATE). Available at <http://research.create.usc.edu/cgi/viewcontent.cgi?article=1112&context=nonpublished_reports> (accessed 08 November 2012).

OSCE. See Organization for Security and Co-operation in Europe.

PCOAS/CHS. See Permanent Council of the Organization of the American States/ Committee on Hemispheric Security.

Permanent Council of the Organization of the American States/ Committee on Hemispheric Security. 2007. "Effective Strategies to Mitigate the Threat Posed by the use of Man-Portable Air Defense Systems (MANPADS) by non-State actors." PCOAS/CHS. 08 March. Available at <http://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CDgQFjAA&url=http%3A%2F%2Fscm.oas.org%2Fdoc_public%2FSPANISH%2FHIST_07%2FCP17935T04.doc&ei=zVzTUM6fL4Wp0QX3hYCIBA&usg=AFQjCNEPD_DZPBS5LEE8NBGrFMXrjg2OPg&sig2=Cm6YXagL0nZ_kEkjl4qYlw&bvm=bv.1355534169,d.d2k> (accessed 20 December 2012).

Pena, Charles V. 2005. "Flying the Unfriendly Skies: Defending against the Threat of Shoulder-Fired Missiles". *Policy Analysis* No. 541. Washington, DC: CATO Institute. Also available at <http://www.cato.org/publications/policy-analysis/flying-unfriendly-skies-defending-against-threat-shoulderfired-missiles> (accessed 08 November 2012).

Peterson, Scott. 2011. "The deadly dilemma of Libya's missing weapons". *Christian Science Monitor*. 07 September. Available at <http://www.csmonitor.com/World/Middle-East/2011/0907/The-deadly-dilemma-of-Libya-s-missing-weapons> (accessed 22 November 2012).

Phelps, Mark. 2003. "Do SAMs pose a real threat to civil aviation?" International Aviation Safety Association. Available at <http://www.iasa.com.au/folders/Security_Issues/dosamspose.html> (accessed 28 November 2012).

Phillips, Zack. 2007 "A Shot in the Dark." *Government Executive,* 15 June. Available at <http://www.govexec.com/magazine/magazine-news-and-analysis/2007/06/a-shot-in-the-dark/24658/> (accessed 29 November 2012).

Pike, John. 2000. "RBS 70." FAS Military Analysis Network. Washington, DC: Federation of American Scientists. Available at <http://www.fas.org/man/dod-101/sys/missile/row/rbs70.htm> (accessed 7 December 2012).

PM/WRA. See Office of Weapons Removal and Abatement. Bureau of Political-Military Affairs. US Department of State.

Porcello, John. 2004. "Ground-Based MANPADS Defense" *Journal of Electronic Defense,* May, pp. 55–59.

Puttre, Michael. 2001. "The air-superiority myth hits the MANPADS mountain." *Facing the Shoulder-Fired Threat*. eDefenseonline.com, 01 April. Available at <http://www.mputtre.com/id21.html> (accessed 28 November 2012).

Pyadushkin, Maxim, Maria Haug and Anna Matveeva. 2003. "Beyond the Kalashnikov: Small Arms Production, Exports, and Stockpiles in the Russian Federation." *Occasional Paper No. 10*. Geneva: Small Arms Survey, August. Available at <http://www.smallarmssurvey.org/fileadmin/docs/B-Occasional-papers/SAS-OP10-Russia.pdf> (accessed 26 November 2012).

Razumkov Centre. 2009. "Ukraine-Russia: From Crisis to Effective Partnership; Section 5: State and Prospects of Ukraine-Russia Cooperation in the Military Sector." *National Security & Defence,* No. 4, pp. 33–36. Kiev: Razumkov Centre.

Available at <http://www.razumkov.org.ua/eng/files/category_journal/NSD108_eng_5.pdf> (accessed 27 November 2012).

RECSA. See Regional Centre on Small Arms in the Great Lakes Region, the Horn of Africa and Bordering States.

Regional Centre on Small Arms in the Great Lakes Region, the Horn of Africa and Bordering States. 2010. "Ethiopia Arms Destruction." Nairobi: RECSA. Available at <http://www.recsasec.org/PDF/Ethiopia_Arms_Destruction.pdf> (accessed 26 November 2012).

Reuters. 2012a. "Huge ammunition explosion rocks Russian city." *Reuters,* 09 October. Available at <http://www.reuters.com/article/2012/10/09/us-russia-explosion-idUSBRE8980XD20121009> (accessed 26 November 2012).

________. 2012b. "Syrian rebels acquire surface-to-air missiles: report". *Reuters,* 31 July. Available at <http://www.reuters.com/article/2012/07/31/us-usa-syria-missiles-idUSBRE86U1T920120731> (accessed 18 September 2012).

RiaNovosti. 2008. "Belarus scraps obsolete portable air defense systems." *RiaNovosti,* 08 December. Available at <http://en.rian.ru/world/20081208/118747764.html> (accessed 26 November 2012).

Rice, Condoleeza. 2008. "Urging Coalition Allies To Approach Beijing on Chinese Proliferation." *Wikileaks.* Available at <http://cablesearch.org/cable/view.php?id=08STATE98975&hl=manpads+iRAQ> (accessed 1 November 2012).

Richardson, E. 2007. "DHS Commercial Airliner Counter-MANPADS Program Progresses" *Journal of Electronic Defense,* Vol. 30, No. 2, February, pp. 16–17.

Richardson, Doug. 2003. "China unveils its Apache killer." *Jane's Missiles and Rockets.* Available at <http://articles.janes.com/articles/Janes-Missiles-And-Rockets-2003/China-unveils-its-Apache-killer.html> (accessed 20 November 2012).

Rivers, Brendan P. 2004. "Flying the Not so Friendly Skies." *Journal of Electronic Defense,* February, pp. 24–28.

Romero, Clyde Jr. 2005. "MANPADS have their limits." *Aviation Week & Space Technology,* Vol. 162, No. 15, 11 April.

RT. See Russia Today.

Russia Today. 2010. "Tanks for the memory." *Russia Today,* 26 February. Available at <http://rt.com/news/tanks-memory/> (accessed 26 November 2012).

________. 2011. "Ammo Depot Inferno: Dozens injured as shells explode at Udmurtia arsenal." *Russia Today,* 03 June. Available at <http://www.youtube.com/watch?v=ft83o63vLRQ> (accessed 26 November 2012).

Rossiskaya Gazetta. 2012. "Vladimir Putin: 'Be strong: guarantees of national security for Russia'." *Rossiskaya Gazetta,* 17 February. Available at <http://www.rg.ru/2012/02/20/putin-armiya.html> (accessed 1 December 2012).

Saab Group. 2011. "The RBS 70 NG VSHORAD system - Transforming the battlefield." 12 September. Available at <http://www.saabgroup.com/Global/Documents%20and%20Images/Campaigns/RBS%2070%20NG/RBS%2070%20NG%20-%20long%20editorial%20110912.pdf> (accessed 21 November 2012).

Sarkar, Debajit. 2012. "VSHORAD – India's Next Big Air Defense Program." *Defense Update,* 1 April. Available at <http://defense-update.com/20120401_vshorad-indias-next-big-air-defense-program.html> (accessed 13 December 2012).

Schaffer, Marvin B. 1998. "The Missile Threat to Civil Aviation." *Terrorism and Political Violence,* Vol.10, No.3. pp. 70–82.

Schroeder, Matt. 2006. "Nicaragua Agrees to Destroy More MANPADS." *FAS Strategic Security Blog.* Washington, DC: Federation of American Scientists, 18 July. Available at <http://www.fas.org/blog/ssp/2006/07/nicaragua_agrees_to_destroy_mo.php> (accessed 26 November 2012).

________. 2007a. "Countering the MANPADS Threat: Strategies for Success". *Arms Control Today,* Vol. 37, September. Washington, DC: Arms Control Association. Available at <http://www.armscontrol.org/act/2007_09/CoverStory> (accessed 08 November 2012).

________. 2007b. “Global Efforts to Control MANPADS.” In Stockholm International Peace Research Institute. *SIPRI Yearbook 2007: Armaments, Disarmaments and International Security.* Oxford: Oxford University Press, pp. 623–39.

________. 2007c. “Video Shows Somali Insurgent with Sophisticated SA-18 Missile.” *FAS Strategic Security Blog.* Washington, DC: Federation of American Scientists, 19 June. Available at <http://www.fas.org/blog/ssp/2007/06/video_shows_somali_insurgent_w.php> (accessed 22 November 2012).

________. 2008. “Missile Watch #3: Black Market Missiles Still Common in Iraq.” *FAS Strategic Security Blog.* Washington, DC: Federation of American Scientists, 8 December. Available at<http://www.fas.org/blog/ssp/2008/12/missile-watch-3-black-market-missiles-still-common-in-iraq.php> (accessed 15 August 2012).

________. 2009. “Latest Missile Plot had Little Chance of Success, but ‘Stinger Stings’ are Valuable Tools.” *FAS Strategic Security Blog.* Washington, DC: Federation of American Scientists, 22 May. Available at <http://www.fas.org/blog/ssp/2009/05/latest-missile-plot-had-little-chance-of-success-but-%E2%80%98stinger-stings%E2%80%99-are-valuable-tools.php> (accessed 26 November 2012).

________. 2010. “International Transfers of MANPADS, 2009 As reported to the UN Register of Conventional Arms.” Federation of American Scientists. Available at <http://www.fas.org/programs/ssp/asmp/issueareas/manpads/International_Transfers_of_MANPADS_2009.pdf> (accessed 17 December 2012).

________. 2011. “Holy grails: Libya loses control of its MANPADS.” *Jane’s Intelligence Review,* Vol. 23, No. 05, pp. 18–22.

________. 2012. “MANPADS for Hezbollah?” *FAS Strategic Security Blog.* Washington, DC: Federation of American Scientists, 16 August. Available at <http://www.fas.org/blog/ssp/2006/08/manpads_for_hezbollah.php> (accessed 1 December 2012).

Schroeder, Matt and Matt Buongiorno. 2010a. “Missile attack on Mogadishu airport foiled by peace-keepers, according to UN report” *Missile Watch,* Vol. 3, No. 2, June, p. 13. Available at <http://www.fas.org/programs/ssp/asmp/issueareas/manpads/Missile_Watch_Vol3_Issue2_June2010_final.pdf> (accessed 09 November 2012).

________. 2010b. “Black Market Prices for Man-Portable Air Defense Systems”. Washington, DC: Federation of American Scientists, June 2012. Available at <http://www.fas.org/programs/ssp/asmp/issueareas/manpads/black_market_prices.pdf> (accessed 09 November 2012).

Seche, Stephen. 2009. “Progress on US-ROYG Cooperation to Reduce MANPADS Threat.” *Cable 09SANAA1402.* Washington, DC: US Department of State. Available at <http://wikileaks.org/cable/2009/08/09SANAA1402.html> (accessed 13 November 2012).

Shapiro, Andrew J. 2012. “Addressing the Challenge of MANPADS Proliferation.” Washington, DC: US Department of State, 02 February. Available at <http://www.state.gov/t/pm/rls/rm/183097.htm> (accessed 22 November 2012).

Silverstein, Ken and Judy Pasternak. 2003. “A Market in Missiles for Terror.” *Los Angeles Times,* 06 March. Available at <http://articles.latimes.com/print/2003/mar/06/world/fg-sams6> (accessed 13 November 2012).

SIPRI. See Stockholm International Peace Research Institute.

Siuris, George M. 2004. *Missile guidance and control systems.* New York: Springer.

Small Arms Survey. 2009. “Supply and demand: Arms flows and holdings in Sudan.” *Sudan Issue Brief,* No. 15. Geneva: SAS, December. Available at <http://www.smallarmssurveysudan.org/fileadmin/docs/issue-briefs/HSBA-IB-15-arms-flows-and-holdings-in-Sudan.pdf> (accessed 29 November 2012).

________. 2012. “Guided Light Weapons Reportedly Held by Non-State Armed Groups 1998-2012.” Geneva: SAS, September. Available at <http://www.smallarmssurvey.org/fileadmin/docs/M-files/armed-groups-guided-missiles.pdf> (accessed 09 November 2012).

________. 2012b. “Unplanned Explosions at Munitions Sites.” 19 October. Available at <http://www.smallarmssurvey.org/?uems> (accessed 26 November 2012).

Smith, Gordon. 1989. "Battle Atlas Of The Falklands War 1982 by Land, Sea and Air." *Naval History Net*. Available at <http://www.naval-history.net/F64argaircraftlost.htm> (accessed 10 December 2012).

SpotterXY. 2009. "Mi-24 Hind vs. 9K38 Igla." Available at <http://www.youtube.com/watch?v=qy5UMCMjkN4&feature=player_detailpage> (accessed 3 December 2012).

Stewart, Scott. 2012. "The Continuing Threat of Libyan Missiles." Security *Weekly*. Stratfor Global Intelligence, 3 May. Available at <http://www.stratfor.com/weekly/continuing-threat-libyan-missiles> (accessed 08 November 2012).

Stimmekoreas. 2012. "Big North Korean Military Exercise with exploding Ships and Planes!" March. Available at <http://www.youtube.com/watch?v=8rZhxefhDBs&feature=player_detailpage> (accessed 15 November 2012).

Stockholm International Peace Research Institute. 2012. "SIPRI Arms Transfer Database." Stockholm: SIPRI. Available at <http://www.sipri.org/databases/armstransfers> (accessed 14 November 2012).

Stratfor Global Intelligence. 2010. "Man-Portable Air Defense Systems: A Persistent and Potent Threat." *Security Weekly*. Stratfor Global Intelligence, 1 February. Available at <http://www.stratfor.com/sample/analysis/man-portable-air-defense-systems-persistent-and-potent-threat> (accessed 09 November 2012).

Stratrisks. 2012. "Ukraine wants to secretly export weapons to Armenia." Stratrisks, 15 August. Available at <http://stratrisks.com/geostrat/7542>.

Susman, Louis B. 2009. "U/S Tauscher's Bilateral Mweetings in London with Russian, Chinese, and French Officials." Cable 09LONDON2214. Available at <http://wikileaks.org/cable/2009/09/09LONDON2214.html> (accessed 27 November 2012).

Tamayo, Juan O. 2010. "Missile purchases by Colombia's FARC rebels raises concerns." *US Action News,* 16 February. Available at <http://usactionnews.com/2010/02/missile-purchase-by-colombias-farc-rebels-raises-concerns/> (accessed 22 November 2012).

Taylor, Bill. 2005. "Protecting Civil Aircraft from the MANPADS Threat – Is this a Practical Scenario?" In David H. Titterton, Sean M. Kirkpatrick, Razvan Stoian, Roger Appleby, J. Martyn Chamberlain, Keith A. Krapels (eds.). *Technologies for Optical Countermeasures II; Femtosecond Phenomenall; and Passive Millimetre-Wave and Terahertz Imaging*. Vol. 5989, Bellingham, Washington: SPIE, pp. 598901-1–598901-15.

Taylor, William B. 2007. "Ukraine: MANPADS For Destruction and Countermeasures Development." *Cable 07KYIV1299*. Available at <http://wikileaks.org/cable/2007/05/07KYIV1299.html> (accessed 22 November 2012).

Thakre, Piyush and Vigor Yang. 2010. "Solid propellants." In Richard Blockley and Wei Shyy (eds). *Encyclopedia of Aerospace Engineering.* Hoboken, NJ.: John Wiley & Sons, Ltd. Available at <http://www.yang.ae.gatech.edu/publications/book/Solid%20Propellants.pdf> (accessed 21 November 2012).

Thales Group. 2011. "Starstreak II showcased in Peru." *Press Release,* 16 May. Available at <http://www.thalesgroup.com/Press_Releases/Countries/Documents/2011/110516_Starstreak_II_showcased_in_Peru/> (accessed 21 November 2012).

Think Defence. 2010. "A Walk in the Countryside." Think Defence, 13 September. Available at <http://www.thinkdefence.co.uk/2010/09/a-walk-in-the-countryside/> (accessed 26 November 2012).

Thompson, Loren. 2003. "MANPADS – Scale and Nature of the Threat." Research Study. Arlington, VA: Lexington Institute, 12 November. Available at <http://www.lexingtoninstitute.org/manpads-scale-and-nature-of-the-threat?a=1&c=1129> (accessed 08 November 2012).

Trend. 2012. "Details of Ukrainian Defense Ministry's letter on supply of arms to Armenia become known." *Trend,* 13 August. Available at <http://en.trend.az/news/politics/2055849.html> (accessed 14 November 2012).

Tribune Review. 2010. "Iraq vet gets probation for smuggling weapons" *Tribune Review,* 10 November. Available at <http://triblive.com/x/pittsburghtrib/news/regional/s_708549.html#ixzz270Cc4DUX> (accessed 22.11.2012).

UN. See United Nations.

United Nations. 1997. "Report of the Panel of Governmental Experts on Small Arms." *A/52/298,* 27 August. Available at <http://www.un.org/Depts/ddar/Firstcom/SGreport52/a52298.htmlg> (accessed 12 November 2012).

________. 2001. "Report of the United Nations Conference on the Illicit Trade in Small Arms and Light Weapons in All Its Aspects." *A/CONF.192/15.* Available at <http://www.poa-iss.org/CASAUpload/ELibrary/Report%20and%20PoA%202001%20Conference.pdf> (accessed 27 November 2012).

________. 2004. "Prevention of the illicit transfer and unauthorized access to and use of man-portable air defence systems." *A/RES/59/90.* 17 December. Available at <http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/59/90&Lang=E> (accessed 27 November 2012).

________. 2005. "International Instrument to Enable States to Identify and Trace, in a Timely and Reliable Manner, Illicit Small Arms and Light Weapons." *A/CONF.192/15.* 8 December . Available at <http://www.un.org/events/smallarms2006/pdf/international_instrument.pdf> (accessed 12 November 2012).

________. 2006. "Report of the Monitoring Group on Somalia pursuant to Security Council resolution 1676 (2006)." *S/2006/913.* 22 November. Available at <http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N06/627/40/PDF/N0662740.pdf?OpenElement> (accessed 22 November 2012).

________. 2007. "Report of the Monitoring Group on Somalia pursuant to Security Council resolution 1724 (2006)" *S/2007/436.* 18 July. Available at <http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N07/383/15/PDF/N0738315.pdf?OpenElement> (accessed 22 November 2012).

________. 2008. "Prevention of the illicit transfer and unauthorized access to und use of man-portable air defence systems." *A/RES/62/40.* Available at <http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/62/40&Lang=E> (accessed 27 November 2012).

________. 2012. "Consolidated working document on the implementation of paragraph 5 of Security Council resolution 2017 (2011) 16 March 2012." *S/2012/178.* 26 March. Available at < http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N12/276/06/PDF/N1227606.pdf?OpenElement> (accessed 21 November 2012).

United Nations Office for Disarmament Affairs. 2012. *UN Register on Conventional Arms.* Available at <http://www.un.org/disarmament/convarms/Register> (accessed 20 November 2012).

United Press International. 2003, "Belarus sells Syria hundreds of missiles." UPI, 16 September. Available at <http://www.upi.com/Top_News/2003/09/16/Belarus-sells-Syria-hundreds-of-missiles/UPI-62451063755718/> (accessed 18 January 2013).

United States Army. 1984. "Stinger Team Operations." *Field Manual* No. 44-18-1. Washington, DC: Headquarters Department of the Army, 31 December. Available at <http://armypubs.army.mil/doctrine/DR_pubs/DR_a/pdf/fm44_18_1.pdf> (accessed 13 November 2012).

________. ND. "Introduction to manportable air defense weapon system." US Army Air Defense Artillery School Fort Bliss, Texas. Available at <http://frank.redpin.com/~urbex/AD0575A.pdf> (accessed 16 November 2012).

United States Congress. 2004. "Intelligence Reform and Terrorism Prevention Act." *Public Law 108-458-DEC. 17, 2004.* Available at <http://www.nctc.gov/docs/pl108_458.pdf> (accessed 28 November 2012).

United States Department of Homeland Security. 2010. "Counter-MANPADS Program Results." Homeland Security Science and Technology Directorate. Available at <http://www.fas.org/programs/ssp/asmp/documents/DHSMANPADSReport.pdf> (accessed 19 December 2012).

United States Department of State. 2005. "Protecting Global Aviation: Keeping Nicaraguan Man-Portable Air Defense Systems Out of the Hands of Terrorists." *Briefing at the Washington Foreign Press Center 24.06.2005.* Available at <http://2001-2009.state.gov/t/pm/rls/rm/49432.htm> (accessed 26 November 2012).

________. 2008. China Conventional Arms Transfers to Iran. Available at <http://wikileaks.org/cable/2008/05/08STATE50524.html> (accessed 13 December 2012).

________. 2011. “United States Helps Croatia Improve Arms Stockpile Security and Destroy Excess MANPADS.” *Press Release 30 November*. Available at <http://www.state.gov/r/pa/prs/ps/2011/11/177958.htm> (accessed 26 November 2012).

United States General Accounting Office. 2004. “Nonproliferation. Further improvements needed in U.S. efforts to counter threats from man-portable air defense systems.” Available at < http://www.gao.gov/assets/250/242320.pdf > (accessed 20 December 2012).

UNODA. See United Nations Office for Disarmament Affairs.

UPI. See United Press International.

Urban, Mark. 1989. *War in Afghanistan* (2nd edition). New York: St. Martin’s Press.

US. See United States.

Venezueladefensa. 2011. “Los Misiles Antiaéreo Iglas-S en Venezuela.” Available at <http://www.youtube.com/watch?v=-e-38NA3ClU> (accessed 15 August 2012).

Vergnolle, Jean-Francois. 2007. “The European Project CASAM for the protection of commercial airliners in flight.” In David H. Titterton and Mark A. Richardson (eds.). *Technologies for Optical Countermeasures* IV, Vol. 6738. Bellingham, Washington: SPIE, pp. 67380I-1–67380I-10.

Vollin, Jeff. “Vigilant Eagle: Ground-Based Countermeasure System Against MANPADS.” In Theodore T. Saito and Daniel Lehrfeld (eds.). *Optics and Photonics.* In Global Homeland Security II Vol. 6203, Bellingham, Washington: SPIE, pp. 62030F-1–62030F-6.

WA. See Wassenaar Arrangement Secretariat.

Wassenaar Arrangement Secretariat. 2012. *Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies - Basic Documents.* January. Available at <http://www.wassenaar.org/publicdocuments/2012/Basic%20Documents%202012.pdf> (accessed 27 November 2012).

Wagstaff-Smith, Keri. 2010. “Solving the SAM threat.” *Jane’s Defence Weekly,* Vol. 47, No. 48, pp. 28–31.

Watson, Leon. 2012. “Soldier smuggled cache of guns from Iraq to Britain in a tank and claims he took them to keep as collector’s item.” *MailOnline.* 20 August. Available at <http://www.dailymail.co.uk/news/article-2190930/Soldier-smuggled-cache-guns-Iraq-Britain-tank-claims-took-collectors-item.html?ito=feeds-newsxml> (accessed 22 November 2012).

Wedeman, Ben and Ingrid Formanek. 2011. “Libyan missiles looted.” *CNN,* 07 September. Available at <http://security.blogs.cnn.com/2011/09/07/exclusive-libyan-missiles-looted/> (accessed 21 November 2012).

Whitmire, James. 2006. “Shoulder Launched Missiles (a.k.a. MANPADS): The Ominous Threat to Commercial Aviation.” *The Counterproliferation Papers,* Future Warfare Series No. 37. Maxwell Air Force Base: USAF Counterproliferation Center. Available at <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA461534> (accessed 12 November 2012).

Williscroft, Robert G. 2006. *The Chicken Little Agenda: Debunking “Experts” Lies.* Gretna, LA: Pelican Publishing Company.

Wisotzki, Simone. 2007. “MANPADS: Herausforderungen für die Rüstungskontrolle und Nichtverbreitung.” *HSFK-Report,* No. 12. Frankfurt a. M: Hessische Stiftung Frieden- und Konfliktforschung. Available at <http://hsfk.de/fileadmin/downloads/report1207.pdf> (accessed 13 November 2012).

Withey, Martin D. 2010. “Infrared countermeasure flares.” *Imaging Science Journal,* Vol. 58, pp. 295–99.

Yildirim, Zeki. 2008. “Self-defense of large aircraft.” Naval Postgraduate School. Available at <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA480080> (accessed 19 November 2012).

Appendix A

Estimated World MANPADS Stockpiles Based on Available Publications

State name	Type	Import	Date(s)	Manufacturer
Afghanistan	Igla-1E/SA-16	?	?	Bulgaria
	Igla-1/SA-16	100	1999/2000	Russia+Lic.
	HN-5A/B	400	1982	China
	Strela-2/SA-7a/b	?	1972	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
Afghanistan (NSAG)	Blowpipe	350	1986/87	UK
	FIM-43C Redeye	50	1984/85	United States
Albania	HN-5A/B	100	1978	China
Algeria	Strela-2/SA-7a/b	1.000	1975/76	Russia+Lic.
Angola	Strela-2/SA-7a/b	1.000	1981	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	150	1990	Russia+Lic.
Argentina	Strela-2/SA-7a/b	?	1987/88	Russia+Lic.
	RBS-70 & Bolide	?	?	Sweden
	Blowpipe	8	1981	UK
Armenia	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-M/SA-18	200	1995/96	Russia
Australia	RBS-70 & Bolide	250	1987/2003/07	Sweden
Austria	Mistral 1	500	1996	France
Azerbaijan	Strela 3/SA-14	18	2008	Ukraine
	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Bahrain	RBS-70 & Bolide	161	1980/81	Sweden
	FIM-92 Stinger	14	1988	United States+ESC
Bangladesh	HN-5A	50	1992	China
	HN-5A/B	2.000	1991/92	China
	HN-5A	21	2001	China
	QW-2	250	2007	China
	RBS-70 & Bolide	?	?	Sweden
Belarus	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
	Igla-M/SA-18	?	?	Russia
Belgium	Mistral	290	1994	France
	Mistral 1	714	1995	France

Destroyed	Date(s)	Stockpile estimate	Comments
		0	
		100	
		400	
101	2007	0	Unclear which type was destroyed, but likely SA-7s, since oldest.
		0	
		350	
		50	
100		0	Destruction data doesn't specify type, but it's likely that all MANPADS were destroyed.
		1,000	
		1,000	
		0	
		150	
? (all?)		0	
		0	
		0	
		0	
		0	
		200	
		250	With 49 launchers
		500	63 or 76 launchers
		18	10 launchers
		0	As basis for local version
		0	
		161	With 14 launchers
		14	
		50	
		2,000	
		21	
		250	
		0	
29 (all?)	2003-08	0	
		0	Jane's says all Belarusian missiles were destroyed.
		0	
		0	
		290	
		714	

State name	Type	Import	Date(s)	Manufacturer
Benin	Strela-2/SA-7a/b	?	?	Russia+Lic.
Bolivia	HN-5A	30	1995	China
	HN-5A/B	28	1985	China
Bosnia-Herzegovina	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Botswana	Strela-2/SA-7a/b	60	1988	Russia+Lic.
	Igla-1/SA-16	50	1996	Russia+Lic.
	Javelin	25	1986/92	UK
Brazil	Mistral	160	1997	France
	Mistral 1	290	1994	France
	Mistral 1	320	1997	France
	Igla-1/SA-16	?	?	Russia+Lic.
	Igla-M/SA-18	168	1994	Russia
	RBS-70 & Bolide	?	?	Sweden
Brunei	Mistral	48	1999	France
	Mistral	24		France
	Mistral	24	2006	France
Bulgaria	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	200	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Burkina Faso	Strela 3/SA-14	18	1999	Ukraine
	Strela-2/SA-7a/b	?	?	Russia+Lic.
Burundi	Strela-2/SA-7a/b	?	?	Russia+Lic.
Cambodia	FN-6 (possibly FN-15)	50	2009	China
	HN-5A/B	1.000	1982	China
	Strela-2/SA-7a/b	233	?	Russia+Lic.
Canada	Blowpipe	55	1982/83	UK
	Starburst	100	1992	UK
Cape Verde	Strela-2/SA-7a/b	?	?	Russia+Lic.
Chad	Strela-2/SA-7a/b	8	?	Russia+Lic.
	FIM-43C Redeye	130	1983/86	United States
	FIM-92 Stinger	30	1987	United States+ESC

Destroyed	Date(s)	Stockpile estimate	Comments
		0	
?	2006	0	Unclear how many were destroyed, but most likely all
?	2006	0	Destroyed with US Government aid
4,749	2003/04	0	According to Jane's
		0	There are no import numbers, but it islikely, that the whole stockpile was destroyed
43	2003/04	0	
		60	
		50	
		25	
		160	For SIMBAD
		290	For ATLAS
		320	
		0	
		168	
		0	
		48	
		24	
		0	
		200	
		0	
		18	
		0	
312	?	0	Destruction: http://www.state.gov/t/pm/rls/fs/169139.htm
		50	
		1	
233	?	0	http://www.armscontrol.org/act/2007_09/CoverStory#23
55	2009/10	0	Communication with National Defence, Government of Canada
100	2009/10	0	Communication with National Defence, Government of Canada
		0	
?	?	8	http://www.armscontrol.org/act/2007_09/CoverStory#23
		130	
		30	

State name	Type	Import	Date(s)	Manufacturer
Chile	Mistral	750	1997	France
	Blowpipe	148	1982	UK
	Javelin	?	?	UK
	FIM-92 Stinger	378	?	United States+ESC
China	Strela-2/SA-7a/b	?	?	Russia+Lic.
	HN-5	?	1976/84	China
	QW-1	?	?	China
	QW-2	?	1998/2002	China
	QW-3	?	2001	China
	QW-4	?	?	China
	QW-11	?	?	China
	QW-18	?	2006/10	China
	FN-6	?	?	China
	FN-16	?	?	China
Colombia	Mistral	?	?	France
Colombia (FARC)	Igla-M/SA-18	?	?	Russia
Croatia	Strela-2/SA-7a/b	500	?	Russia+Lic.
	Strela-3/SA-14	500	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
	FIM-92 Stinger	120	?	United States+ESC
Cuba	Strela-2/SA-7a/b	100	?	Russia+Lic.
	Strela-3/SA-14	?	1966/67	Russia+Lic.
	Igla-1/SA-16	100	1989/90	Russia+Lic.
Cyprus	Strela-2/SA-7a/b	50	?	Russia+Lic.
	Mistral	90	1989	France
	Mistral		2005?	France
Czech Republic	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	200	1984	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
	Igla-M/SA-18	?	2010	Russia
	RBS-70 & Bolide	16	2007	Sweden
DR Congo	Strela-2/SA-7a/b	10	?	Russia+Lic.
Denmark	FIM-92 Stinger	940	1991/96	United States+ESC
Ecuador	Igla-1E/SA-16	20	?	Bulgaria
	Igla-1/SA-16	242	1998	Russia+Lic.
	Igla-M/SA-18	50	2001	Russia
	Mistral-1	100	1998	France

Destroyed	Date(s)	Stockpile estimate	Comments
		750	
		148	
		0	
		378	
		0	Estimation: 46,000 MANPADS
		0	
		0	
		0	
		0	
		0	Still in development?
		0	Development complete?
		0	
		0	
		0	
		0	
		0	Via Venezuela or theft from Peru
1,000	2011	0	Destruction not specified, but most likely Strela 2 and 3
		0	
		0	
		120	
		100	
		0	
		100	
324	2009	50	Including 101 gripstocks: http://www.state.gov/t/pm/rls/fs/169139.htm
		90	
		0	
		200	
		0	
		0	
		16	
		10	
		940	
		20	
		242	
		50	
		100	

State name	Type	Import	Date(s)	Manufacturer
Egypt	Strela-2/SA-7a/b	10.000	?	Russia+Lic.
	Igla-M/SA-18	600	2007	Russia
	FIM-92 Stinger	1.478	1991/2003/08	United States+ESC
	Sakr Eye	?	1987	Egypt
El Salvador	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
Eritrea	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Igla-M/SA-18	259	1995/99	Russia
Estonia	Mistral-1	?	2009	France
	Mistral-2	100	2008	France
Ethiopia	Strela-2/SA-7a/b	1.550	?	Russia+Lic.
Finland	Mistral-1	540	1989	France
	Strela-2/SA-7a/b	200	?	Russia+Lic.
	Strela-3/SA-14	105	1986/87	Russia+Lic.
	Igla-1/SA-16	90	1986	Russia+Lic.
	Igla-M/SA-18	100	1990	Russia
	RBS-70 & Bolide	128	2008	Sweden
France	FIM-92 Stinger	50	1983	United States+ESC
	Mistral-1	5.000	1988	France
	Mistral-2	800	2000	France
Gabon	Mistral-1	60	1988	France
Gaza & West Bank	Igla-1E/SA-16	?	2005	Bulgaria
	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-M/SA-18	?	2005	Russia
	Igla-S/SA-24	?	?	Russia
	Sakr Eye	?	?	Egypt
Georgia	Grom	?	2007/08	Poland
	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Germany (DDR)	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.

Destroyed	Date(s)	Stockpile estimate	Comments
		10,000	
		600	
		1,478	
		0	
		0	
		0	
		0	
		259	
		0	
		100	
1	2010	1,549	Unclear where the destroyed MANPADS came from. Found in a police station.
		540	
		200	
		105	
		90	
		100	
		128	
		50	
		5,000	
		800	
		60	
		0	Rumored
		0	
		0	
		0	
		0	
		0	
		0	
		0	
		0	
		0	
		0	
		0	
		0	

State name	Type	Import	Date(s)	Manufacturer
Germany	Igla-M/SA-18	?	?	Russia
	RBS-70 & Bolide	16	2007	Sweden
	FIM-92 Stinger	4.500	2004	United States+ESC
	FIM-92 Stinger	12.500	?	ESC
Ghana	Strela-2/SA-7a/b	?	?	Russia+Lic.
Greece	FIM-92 Stinger	1.500	1994	United States+ESC
	FIM-92 Stinger	1.732	?	ESC
Guinea	Strela-2/SA-7a/b	?	?	Russia+Lic.
Guinea-Bissau	Strela-2/SA-7a/b	?	?	Russia+Lic.
Guyana	Strela-2/SA-7a/b	?	?	Russia+Lic.
Hungary	Igla-1E/SA-16	?	1999	Bulgaria
	Igla-M/SA-18	?	?	Russia
	Mistral-1	180	1999	France
	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	300	1987/89	Russia+Lic.
India	Mistral-1	20	?	France
	Strela-2/SA-7a/b	500	?	Russia+Lic.
	Strela-3/SA-14	600	1995/97	Russia+Lic.
	Igla-1/SA-16	2.500	1990/91	Russia+Lic.
	Igla-M/SA-18	2.500	1001/03	Russia
	Igla-S/SA-24	?	?	Russia
Indonesia	QW-3	130	2007	China
	QW-3	80	2009	China
	QW-3	15	2010	China
	Mistral-1	?	2006	France
	Mistral-2	?	2006	France
	Grom	2	2010	Poland
	Igla-1/SA-16	16	2003	Russia+Lic.
	RBS-70 & Bolide	150	1982	Sweden
Iran	HN-5A	500	1988	China
	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-M/SA-18	?	?	Russia
	RBS-70 & Bolide	200	1985	Sweden
	Misagh-1	?	?	Iran
	Misagh-2	550	2006/09	Iran

Destroyed	Date(s)	Stockpile estimate	Comments
		0	There is contradictory information on Jane's compared with equipment information in the 2012 *Military Balance*.
		16	
		4,500	
		12,500	
		0	
		1,500	
		1,732	
		0	
		0	
		0	
		0	
		0	
		180	
1,540	2005/06	0	Most likely that's all there were of the Strela-2.
		300	
		20	
		500	
		600	
		2,500	
		2,500	
		0	
		130	ATLAS on local vehicle
		80	
		15	
		0	
		0	
		2	
		16	
		150	
		500	
		0	
		0	
		0	
		200	
		0	
		550	

State name	Type	Import	Date(s)	Manufacturer
Iraq	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Misagh-1	?	?	Iran
Ireland	RBS-70 & Bolide	20	2007/08	Sweden
Israel	FIM-92 Stinger	344	1996	United States+ESC
Italy	Mistral-1	?	?	France
	FIM-92 Stinger	700	1988/2002/04	United States+ESC
Japan	FIM-92 Stinger	937	1988/91/2008	United States+ESC
	Type-93 Kin-Sam	18	1993	Japan
	Type-91 Kin-Sam	90+	1991	Japan
Jordan	Igla-S / SAM-18	182	2007	Russia
	Mistral-1	?	?	France
	Strela-2/SA-7a/b	300	?	Russia+Lic.
	Strela-3/SA-14	200	1987	Russia+Lic.
	Igla-1/SA-16	240	?	Russia+Lic.
	Igla-M/SA-18	1.900	2001/09/10	Russia
	Igla-S/SA-24	200	2008	Russia
	Starburst	?	?	UK
Kazakhstan	Strela-2/SA-7a/b	250	?	Russia+Lic.
	Strela-3/SA-14	50	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Kenya	Mistral-1	100	1992	Russia+Lic.
Korea, North	HN-5A/B	600	1983-94	China
	Strela-2/SA-7a/b	250	?	
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	1.250	?	Russia+Lic.
	Igla-M/SA-18	?	?	Russia
Korea, South	Chiron	2.000	2006-?	South Korea
	Mistral	984	1997	France
	Mistral	1742	2000	France
	Igla-1E/SA-16	?	?	Bulgaria
	Igla-1/SA-16	?	?	Russia+Lic.
	Igla-M/SA-18	48	?	Russia
	Javelin	?	1986	UK
Kosovo	Strela-3/SA-14	?	1999	Russia+Lic.

Destroyed	Date(s)	Stockpile estimate	Comments
		0	
		0	
		20	
		344	+ undisclosed number in second shipment.
		0	
		700	
		937	
		18	
		90	Possibly more
		182	
		0	
300	?	0	By NAMSA and US / Personal Communications F.P.
		200	
		240	
			Replacement for Strela-2 (Strela-2 destroyed?).
		0	
300	2010	0	By NAMSA and US / Since ex-Soviet state, there are probably more in stocks.
		50	
		0	
		100	
		600	
		250	
		0	
		1,250	
		0	
		2,000	
		984	
		1,742	130 launchers
		0	
		0	
		48	
		0	
		0	

State name	Type	Import	Date(s)	Manufacturer
Kuwait	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	500	1985	Russia+Lic.
	Starburst	250	1995	UK
	Sakr Eye	36	1989/90	Egypt
Kyrgyzstan	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Laos	Strela-2/SA-7a/b	100	1984	Russia+Lic.
	Igla-1/SA-16	50	1999	Russia+Lic.
	Igla-M/SA-18	50	2005	Russia
Latvia	RBS-70 & Bolide	102	2006/07	Sweden
Lebanon	Strela 2/SA-7	100	1997	?
	QW?	?	?	China
	Strela-2/SA-7a/b	250	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Lebanon (Hizbolla)	Misagh-1	?	?	Iran
Liberia	?	?	?	?
Libya	Strela 2/SA-7	1.500	1982	Russia
	Strela 2 MA	?	?	Jugoslavia
	Strela 2m/SA-7b	1.500	1982	Russia
	Igla-S/SA-24	24	2004	Russia
	Igla-S/SA-24	482	?	Russia
	Strela 3/SA-14	?	<2010	Russia
Lithuania	RBS-70 & Bolide	281	2004/05	Sweden
	FIM-92 Stinger	62	2007	United States+ESC
Macedonia	Igla-1/SA-16	?	?	Russia+Lic.
Malawi	Blowpipe	70	1985	UK
Malaysia	FN-6	64	2009	China
	FN-6	16	2010	China
	Mistral-1	?	?	France
	Igla-M/SA-18	40	2002	Russia
	Igla-S/SA-24	?	?	Russia
	RBS-70 & Bolide	?	2008	Sweden
	Javelin	12	1991	UK
	Starburst	504	1995/97	UK
	Anza MK-II	500	2003	Pakistan
Mali	Strela-2/SA-7a/b	40	?	Russia+Lic.

Destroyed	Date(s)	Stockpile estimate	Comments
		0	
		500	
		250	50 launchers
		36	
		0	
		0	
		0	
		100	
		50	
		50	
		102	
		100	
		0	Hisbollah
		250	
		0	
		0	
		0	
45	2007	0	Probably all destroyed.
		1,500	
5,000	2012	0	Unclear which types were destroyed, but probably no SA-24s.
		1,500	
		24	In Strelets vehicle-mounted configuration
		482	CSMonitor 2011
		0	
		281	
		62	Mounted version
156	?	0	Destruction: http://www.state.gov/t/pm/rls/fs/169139.htm
		70	With 14 launchers
		64	
		16	
		0	
		40	
		0	not confirmed
		0	
		12	Maybe even 48 / source unclear.
		504	
		500	
		0	

State name	Type	Import	Date(s)	Manufacturer
Mauritania	Strela-2/SA-7a/b	100	?	Russia+Lic.
Mauritius	Strela-2/SA-7a/b	?	?	Russia+Lic.
Mexico	Igla-M/SA-18	?	?	Russia+Lic.
	Igla-S/SA-24	?	2003	Russia
Moldova	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Mongolia	Strela-2/SA-7a/b	?	?	Russia+Lic.
Montenegro	Strela-2/SA-7a/b	?	?	Russia+Lic.
Morocco	Strela-2/SA-7a/b	200	1981	Russia+Lic.
Mozambique	Strela-2/SA-7a/b	?	?	Russia+Lic.
Myanmar	HN-5A	200	1992	China
	Strela 2/SA-7	10	1995	Cambodia
	Igla-1/SA-16	100	1999	Bulgaria
	Igla-M/SA-18	20	?	Russia
Namibia	Strela-2/SA-7a/b	?	?	Russia+Lic.
Netherlands, The	FIM-92 Stinger	1.594	1985/2003	United States+ESC
New Zealand	Mistral-1	39	1998	France
Nicaragua	Strela-2/SA-7a/b	1.151	1982-85	Russia+Lic.
	Strela-3/SA-14	117	1986/87/91	Russia+Lic.
	Igla-1/SA-16	360	1987/88	Russia+Lic.
Nicaragua (Contras)	FIM-43C Redeye	300	1986/87	United States
Nigeria	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Blowpipe	200	1983/84	UK
Norway	Mistral-1	400	1997	France
	RBS-70 & Bolide	5.550	1981/84/87/90/92	Sweden
Oman	Mistral-1	230	?	France
	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Blowpipe	200	1985/86	UK
	Javelin	280	1984/90	UK
	Sakr Eye	?	?	Egypt
Pakistan	HN-5A/B	1.100	1987-98	China
	QW-1	1.350	2008	China
	FN-6	?	?	China
	Mistral-1	50	2010	France
	RBS-70 & Bolide	1.205	1986-88/2008	Sweden
	FIM-92 Stinger	150	1985/87	United States+ESC
	Anza MK-II	?	1994	Pakistan
	Anza MK-III	?	2006	Pakistan

Destroyed	Date(s)	Stockpile estimate	Comments
141	2012	0	Probably all destroyed.
		0	
		0	
		5	
		0	
		0	
		0	
		0	
1,500	?	0	Destruction: http://www.state.gov/t/pm/rls/fs/169139.htm
		200	
		0	
		200	
		10	
		100	
		20	
		0	
		1,594	
		39	
1,000	05/07.2004	151	Destruction see Jane's
		117	
		360	
		300	
		0	
		200	
		400	
		5,550	
		230	
		0	
		200	
		280	
		0	
		1,100	
		1,250	
		0	
		50	
		1,205	
		150	
		0	
		0	

State name	Type	Import	Date(s)	Manufacturer
Peru	Igla-1E/SA-16	190	1994	Bulgaria
		21	1995	Bulgaria
	Igla-1/SA-16	838	1992-96	Russia+Lic.
	FN-6	25	2009	China
	Strela-2/SA-7a/b	500	1978-81	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-M/SA-18	?	?	Russia
	Javelin	200	1995	UK
Poland	Strela-2/SA-7a/b	1.000	1970-71	Russia+Lic.
	Strela-3/SA-14	100	1987	Russia+Lic.
	Grom-1	?	1995	Poland
	Grom-2	200-300	2000	Poland
Portugal	Blowpipe	60	1983	UK
	FIM-92 Stinger	30	1996	United States+ESC
Qatar	Mistral-1	500	1996	France
	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Blowpipe	50	1985/86	UK
	FIM-92 Stinger	12	1988	United States+ESC
Republika Srpska	?	?	?	?
Romania	Mistral-1	?	?	France
	Strela-2/SA-7a/b	?	?	Russia+Lic.
	CA-94	?	?	Romania
Russia	Strela-2/SA-7a/b	5.000+	1968-?	Russia+Lic.
	Strela-3/SA-14	2.500+	1974-?	Russia+Lic.
	Igla-1/SA-16	500+	1981-?	Russia+Lic.
	Igla/SA-18	500+	1983-?	Russia
	Igla-S/SA-24	?	2002-?	Russia
Rwanda	Igla-1/SA-16	?	<1994	Russia+Lic.
Saudia Arabia	Mistral-1	1	2009	France
	Mistral-2	200	2008	France
	Igla-1/SA-16	?	?	Russia+Lic.
	FIM-43C Redeye	310	1979/80	United States
	FIM-92 Stinger	600	1984/90	United States+ESC
Serbia	Igla-1/SA-16	226	1995	Russia+Lic.
	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	45	?	Russia+Lic.
Seychelles	Strela-2/SA-7a/b	50	1979-80	Russia+Lic.

Destroyed	Date(s)	Stockpile estimate	Comments
		190	56 launchers
		21	"systems"
		838	
		25	
		500	
		0	
		0	
		200	
		1,000	
		100	
		0	
		300	
		60	
		30	
		500	
		0	
		50	
		12	
1,077	2003	0	Probably old Yugoslavian stocks.
		0	
		0	
		0	
		5,000	Estimation: 46–140,000 MANPADS
		2,500	
		500	
		500	
		0	
		0	
		1	
		200	
		0	
		310	
		600	
		226	57 launchers
4,280	2007	0	Unclear which type. Agreement was to destroy 5,000, so its likely there are many more in stock.
		45	
		50	

State name	Type	Import	Date(s)	Manufacturer
Sierra Leone	Strela 2/SA-7	5	1999	Ukraine
Singapore	Mistral-1	500	1996	France
	Igla-M/SA-18	1.050	1998/99	Russia
	RBS-70 & Bolide	500	1980/81	Sweden
Slovakia	Strela-2/SA-7a/b	120	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Slovenia	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Igla-1/SA-16	4	2003	Russia+Lic.
Somalia	Strela 2/SA-7	50	1998	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
	Igla-M/SA-18	?	?	Russia
	FIM-43C Redeye	300	1982	United States
South Africa	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Starstreak-I	98	2006	UK
Spain	Mistral-1	200	2008	France
Sri Lanka (LTTE)	Strela 2/SA-7	25	1995	Russia+Lic.
Sri Lanka	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	2006	Russia+Lic.
	Igla-M/SA-18	?	?	Russia
Sudan	FN-6	50	2006	China
	FN-6	10	2010	China
	Strela-2/SA-7a/b	70	1981-84	Russia+Lic.
	Igla-M/SA-18	?	?	Russia
	FIM-43C Redeye	125	1984	United States
Sweden	RBS-70 & Bolide	?	2003/?	Sweden
Switzerland	FIM-92 Stinger	3.500	1996	United States+ESC
Syria	Strela-2/SA-7a/b	15.000	1970	Russia+Lic.
	Strela-3/SA-14	1.500	1987/89	Russia+Lic.
	Igla-M/SA-18	500	2003/06	Russia
	Igla-S/SA-24	?	2002	Russia
Taiwan	Mistral-1	?	?	France
	RBS-70 & Bolide	20	1984	Sweden
	FIM-92 Stinger	2.198	2001/?	
Tajikistan	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Tanzania	Strela-2/SA-7a/b	200	1977(78	Russia+Lic.

Destroyed	Date(s)	Stockpile estimate	Comments
		5	
		500	
		1,050	Some reported tranferred to Myanmar.
		500	
		120	
		0	
		0	
		0	
		4	
		50	
		0	
		0	
		300	
		0	
		0	
		98	
		200	
		25	
		0	
		0	
		0	
		50	
		10	
21	2007	70	Unclear which type.
		0	
		125	
		0	
		3,500	
		15,000	
		1,500	
		500	
		0	
		0	
		20	
12	2012	0	Unclear on how many are in stocks.
		0	
		0	
		200	

State name	Type	Import	Date(s)	Manufacturer
Thailand	HN-5A	500	1987	China
	HN-5A	650	1988	China
	Mistral-1	36	1997	France
	Igla-M/SA-18	?	?	Russia
	Igla-S/SA-24	36	?	Russia
	RBS-70 & Bolide	90	1997/2002/05	Sweden
	Blowpipe	200	1981-84	UK
	FIM-43C Redeye	200	1982/83	United States
Tunisia	Strela-2/SA-7a/b	?	?	Russia+Lic.
	RBS-70 & Bolide	300	1980/81	Sweden
Turkey	FIM-43C Redeye	300	1994	United States
	FIM-43C Redeye	789	1985-?	United States
	FIM-92 Stinger	647	1992/?	United States+ESC
	FIM-92 Stinger	4.800	2004	ESC
Turkmenistan	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Uganda	Strela-2/SA-7a/b	200	1975/87	Russia+Lic.
Ukraine	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	200	?	Russia+Lic.
	Igla-M/SA-18	?	?	Russia
United Arab Emirates	Mistral-1	524	1994	France
	Mistral-2	?	?	France
	Strela-3/SA-14	100	1986/87	Russia+Lic.
	Igla-1/SA-16	400	1998/99	Russia+Lic.
	Igla-M/SA-18	?	?	Russia
	RBS-70 & Bolide	304	1980/81	Sweden
	Blowpipe	100	1981	UK
United Kingdom	Igla-1/SA-16	31	2005/06	Russia+Lic.
	FIM-92 Stinger	200	1982/2004	United States+ESC
	Blowpipe	?	?	UK
	Javelin	295	1989	UK
	Starburst	?	1991	UK
	Starstreak-I	7.000+	1995	UK
	Starstreak-II	?	?	UK

Destroyed	Date(s)	Stockpile estimate	Comments
		500	
		650	
		36	
		0	
		0	
		90	
		200	
		200	Number delivered in 83 shipment could be considerably higher.
		0	
		300	
		300	From Germany
		789	
		647	
		4,800	Likely from European Stinger Consortium
		0	
		0	
		0	
?	2007	0	
3,000	2007	0	Original number unclear / http://www.armscontrol.org/act/2007_09/Cover-Story#23
		0	
		0	
		0	
		524	
		0	
		100	
		400	
		0	
		304	
		100	
		31	
		200	
		0	Out of service, but unclear if destroyed.
		295	Over 16,000 were produced, probably large stockpile.
		0	
		7,000	
		0	

State name	Type	Import	Date(s)	Manufacturer
United States	Igla-1/SA-16	313	2006/07	Russia+Lic.
	Igla-M/SA-18	157	2003/05/06	
	FIM-92 Stinger	379+		United States
Uzbekistan	Strela-2/SA-7a/b	?	?	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	?	?	Russia+Lic.
Venezuela	Mistral1	?	?	France
	Igla-M/SA-18	?	?	Russia
	Igla-S/SA-24	100	2009	Russia
	RBS-70 & Bolide	8	?	Sweden
Vietnam	Strela-2/SA-7a/b	5.080	1971/75/96/99	Russia+Lic.
	Strela-3/SA-14	?	?	Russia+Lic.
	Igla-1/SA-16	100	1996/97	Russia+Lic.
	Igla-M/SA-18	50	2002	Russia
	Igla-S/SA-24	?	?	Russia
Yemen	Strela-2/SA-7a/b	80	1989/91	Russia+Lic.
Zambia	Strela-2/SA-7a/b	100	1979	Russia+Lic.
Zimbabwe	Strela-2/SA-7a/b	?	?	Russia+Lic.
TOTAL				

Sources: Adapted from Jane's, 2011-2012; SIPRI, 2012; IISS, 2012

Destroyed	Date(s)	Stockpile estimate	Comments
		313	Possibly supplied under countermeasure agreement
		157	
		379	Our estimate: 50–90,000 MANPADS
		0	
		0	
		0	
		0	
		0	
		2,400	In delivery
		8	Number “in service” no import number.
		5,080	
		0	
		100	
		50	
		Unknown	
		80	
		100	
		0	
		153,341	

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p. 41 Syrian fighter with SA-16/ Joshua Landis

p. 86 MANPADS in Uganda/ Mines Advisory Group

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