Commercial Aviation and MANPADS: Threat or Theory

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One of the consequences of the September 11 attacks is a more fearful America. This America is willing to spend to defend itself against improbable threats. Concerns over an attack on a commercial jet liner with a shoulder-launched surface to air missile (known by the acronym MANPADS – man portable air defenses systems) fall into this category.

The MANPADS most likely to be used by terrorists can be divided into two generations. The first generation, Blowpipe (UK), Redeye (US), and SA-7 (Russia), along with foreign copies of these missiles (such as China's HN-5), were only moderately successful against small aircraft even when they were new. Later generations of MANPADS, such as the Stinger (US) and the SA-14/16/18 (Russia), were more effective than the earlier missiles. The later generation missiles are faster, have a greater range, and their guidance systems, sensors and fuses are more sophisticated and more likely to guide the missile to hit the aircraft.

Terrorist groups mainly have SA-7s and early model Stingers. These missiles were provided during the Cold War by the superpowers to their proxy forces. Terrorist groups may also have managed to acquire a few SA-14/16/18s, as Soviet-era stockpiles were poorly secured at the end of the Cold War. Of the missiles in terrorist hands, the SA-7 is the most common. The Soviets distributed them widely and versions have been produced by China, Egypt, and Pakistan. These MANPADs pose a limited threat. They are older and less accurate than a Stinger or SA-16.

While there are thousands of SA-7 scattered around the world, held by a variety of governments, armed groups, warlords and mullahs, the number of Stingers and SA-14/16/18s potentially available to terrorists is much smaller. In part, this is because the U.S. has led a concerted international effort for the last ten years to restrict access to MANPADS. The U.S. has also undertaken an effort to repurchase or destroy MANPADS (particularly stingers) given to proxy forces in earlier decades. This decade-long effort to control or repurchase has had some success in restricting access to MANPADS and spare parts and in reducing the stocks available to terrorist groups. The result is that newer and more sophisticated MANPADS are in very short supply and older MANPADS are, after a decade or more of poor maintenance, in uncertain condition.

Each model of MANPAD is different, but there are common features. MANPADs have six key parts – a rocket motor, an explosive warhead, a fuse, a sensor, a microelectronic 'brain' and a battery to power these devices. The operator looks through a small sight to visually acquire the target aircraft. In many models, the missile emits an audible tone to let the operator know it has detected an aircraft and when it has locked on to the target and can be fired. The operator then pulls a trigger to release the missile. MANPADS used by terrorists are 'fire-and-forget' – once released, the missile no longer requires inputs from the operator. However, the operator needs some training to be effective. An untrained operator is likely to miss even if there is a lock-on at launch, if the aircraft is too far away or moving too quickly. We know that some terrorist groups have trained operators, particularly for the SA-7, but also for the Stinger and perhaps the SA-14.

Once launched, the sensor directs the missile to the aircraft. The missile accelerates rapidly to one or two times the speed of sound. As the missile closes with or hits the target, the fuse detonates the warhead. The missile is not tracking the aircraft per se, but a hot point on the aircraft. The explosion and fragments from the missile damage the engine but do not always down the plane. As the MANPADS approaches the aircraft, it will usually orient itself to the back of the engine, the hottest point, and detonate there.

Early MANPADS could only be fired at an aircraft after it had passed overhead and the hot engine exhaust was visible. Later generation of MANPADS used more sophisticated sensors and guidance systems that could detect an aircraft's heat signature from the front or side. The sensor detects heat from an aircraft and uses that heat signature to track the target. To work, the sensors must be supercooled, using liquid nitrogen.

Maintenance of the MANPADS is a crucial problem, particularly for terrorist groups that may have limited or no access to spare parts and services. Batteries must be replaced periodically, but since they are specially designed to fit the missile, they are not commercially available. The sensor is the most sensitive parts of the missile. The SA-7, Stinger and SA-14/16/18 use infrared sensors that are cooled to well below the outside temperature. These sensors require special handling and their performance degrades over time without maintenance. The missile may still launch from its tube, but it will have trouble tracking the aircraft and will be less likely to hit. Although MANPADS are designed to be robust, the years of clandestine storage and poor maintenance means that many black-market missiles are unreliable.

MANPADS were designed to work best against smaller, single engine aircraft (such as a fighter or military helicopter). Commercial jet liners have an advantage over military aircraft in this regard. They are larger and multi-engined. Their engines are usually hung from a wing rather than being an integral part of the aircraft structure. They are designed to survive the catastrophic failure of one engine. The MANPADS warhead is too small to damage the wing through blast, so structural failure is unlikely.

MANPADS must be light enough to be carried. Weight limitations constrain MANPADS capabilities (the missiles weigh between 25 and 40 pounds, and the warhead usually weighs between 3 and 6 pounds. This small size limits the damage the missile can do to an aircraft. This limits maximum range to about 3 to 5 miles, and effective range (where the missile is likely to hit the aircraft) is a fraction of this. For the greatest chance of success, an aircraft must be fairly low to the ground and close to the launch point. For a commercial flight, the best attack would be as the aircraft takes off, when it is heavily laden with fuel and pointing away from the runway. Next best would be as the aircraft approaches for landing. This means that an attack would likely come within in an area within roughly 10 miles distant or less from an airport.

Defensive systems work by trying to confuse or mislead the missile. Since MANPADS use a heat-seeking sensor, this can be done in two ways. A jamming device on the aircraft emits laser or infrared signals that can confuse or divert the missile from the target. The aircraft may dispense multiple flares every few seconds. The falling flare is detected by the missiles sensor as hotter than the aircraft's engine and the missile will chase the flare, not the aircraft. Over time, missile developers have improved guidance software to allow the missile to distinguish between these diversions and its true target, but jamming devices and flares still work. Terrorists are likely to have older, less sophisticated missiles. Finally, a missile warning system can notify the pilot of an attack and allow the opportunity to accelerate and outrun the MANPAD, with its limited range, although some pilots turn off the warning systems to avoid false alerts.

The best defense uses a combination of warning devices, evasive action, jamming devices and flares. A military aircraft approaching an area defended by MANPADS will activate its countermeasures. It will eject flares, and it will engage in abrupt maneuvers. This combination offers the best chance of defeating an incoming MANPADS.

Flares are not an option for commercial aircraft in the United States and many other parts of the world. Since many airports are surrounded by developed areas, an aircraft dispensing flares in its departure or approach every time it took off or landed could leave a trail of fires and damage and would certainly displease local communities. At a minimum, the flares emit frequent, noisy bangs which, for the unprepared, can be frightening.

The alternative is to rely on jamming devices alone. These devices have been made since the 1980s. Early versions did not work very well. In the following decades, these systems have improved, but they are still not 100 percent effective and the better versions are costly. Their use can be seen as a contest between the jamming device and a missile's sensor and software. Upgrading the jamming device means that the missile's sensor or software must also be upgraded if it is to remain effective. Terrorists cannot perform these upgrades, so jamming devices should gain an advantage over MANPADS in terrorist inventories.

The difficulty of acquiring, maintaining and using a MANPADS has led terrorist groups to look to other weapons. Al Qaeda pioneered the use of RPGs (a simple, unguided anti-tank rocket) to attack helicopters. The group that claimed responsibility for shooting down a British C-130 in Iraq said that it had used an anti-tank missile (perhaps a Soviet-era AT-3 or AT-4), but it is unlikely that the video of the attack released by the group can be believed. UK Ministry of Defence sources are quoted as saying the C-130 was shot down by anti-aircraft artillery while flying at a low altitude.

Looking at the record of MANPADS attacks on large aircraft helps us to gauge the actual threat. Several multiengine propeller aircraft have been shot down, including a Viscount in 1978, a C-123 in 1985, a DC-7 in 1988 and a C-130 in 1998. All but one incident occurred in Africa (the C-123 was shot down in Central America).

There have been six attacks against commercial jetliners since these missiles appeared in the 1970s. Three were in Africa, one in Afghanistan, and two in Iraq. Of the six attacks, two (both in Africa) were successful. In 1983, rebels in Angola downed a B-727. In 1998, rebels in the Congo downed a B-727 as it took off. In both cases, the aircraft had inadequate maintenance and the pilots may not have been trained in emergency landing procedures. A 727 (or similar model aircraft, such as the Tupolev 154) is at a disadvantage as the engines are clustered at the rear of the aircraft and attached to the fuselage. In 2002, terrorist fired two SA-7s at an Israeli B-757 taking off in Kenya. Both missiles missed. In 2003, terrorists fired an SA-7 at an A-300 used as a cargo aircraft as it took off from Baghdad. In this case, the missile hit the aircraft, but the plane was able to land safely. In the same year, a missile or rocket of some kind hit an USAF C-17 as it took off from Baghdad, but this aircraft also was able to land safely.

Equipping all U.S. commercial airliners with jamming devices would be expensive. There are between 6800 -7000 commercial aircraft in the U.S. Jamming systems cost between $1.5 and $2 million, making the minimal cost of this program over $10 billion, plus the additional cost of maintenance over the life of the program. The airline industry is in no position to afford this new cost. Given the limited effectiveness of MANPADS against commercial airliners, the difficulties in their operation and use, and the energetic efforts by the U.S. and other nations to prevent their acquisition and use, this may be an investment the nation can afford to forgo. Additional attention to patrolling strategies for large airports and continued spending on research to develop more effective and less expensive jamming systems is worthwhile, but requiring all aircraft of carry them is not justified by the risk

Structural improvements to aircraft could increase the chance of surviving a MANPADS attack. The critical area is where the engine attaches to the wing; fuel cells or control systems near this area are the most vulnerable, but changes in aircraft design (such as the move away from hydraulic controls) have reduced this risk. Improvements to fuel systems (such as the changes in fuel tank design undertaken after Flight 800 exploded off Long island in 1996) to prevent fire or explosion could also reduce the chances of a successful MANPADS attack.

Unlike the movies, an aircraft hit by a MANPADS does not explode into fragments. MANPADS work by making the aircraft uncontrollable, causing it to crash. The principle challenge is that once the aircraft is hit and one of the engines knocked out, the pilot has at best a few minutes to regain control and attempt to return to an airport. Altitude and speed affect recovery time. The lower the aircraft is to the ground, the more likely the attack is to be successful. For commercial airliners, this suggests that the attack would have to occur relatively close to an airport. Pilots with average skills flying large, multi-engine aircraft that are in good condition are likely to survive a MANPADS hit. Smaller regional jets and business jets are more vulnerable. Pilot training on dealing with catastrophic engine failure at low altitude is the single best defense to increase the chances of surviving a MANPADS hit.