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EXERCISE NEW HORIZONS

**THE COMMERCIAL AIRLINE MISSILE DEFENSE ACT AND THE THREAT  
FROM SHOULDER-FIRED, INFRARED SURFACE-TO-AIR MISSILES**

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## Abstract

Legislation was introduced in 2003 to protect American commercial aircraft from the threat of terrorist-launched, infrared-guided missiles. The Commercial Airline Missile Defense Act sought to mandate IR missile defence systems for American-registered airlines. This paper looked at the threat from IR-guided missiles, first from the capabilities of the systems, and then from the potential of terrorist groups obtaining the missiles. A review of military missile defence technology that could be transferred to civilian application was conducted, and it was determined that the proposed Directed Infra-Red Countermeasures system is preferable over other forms of countermeasures, but that its high cost and questionable reliability precludes its large-scale use on commercial aircraft.

Counter to the proposed legislation, which only addresses the IR threat, a number of recommendations were provided to mitigate the threat from all types of missiles. A combination of measures to reduce an aircraft's susceptibility to attack, followed by design changes reducing an aircraft's vulnerability should it be struck by a shoulder-fired missile were presented.

The proposed Commercial Airline Missile Defence Act is too restrictive and costly to offer effective protection against terrorist-launched missiles, and therefore its application could not be supported by the author.

## The Commercial Airline Missile Defense Act and the Threat

### From Shoulder-Fired, Infrared Surface-to-Air Missiles

Once considered a tightly controlled military weapon for targeting aircraft operating within recognized combat zones, man-portable, shoulder-launched, anti-aircraft missiles are increasingly being used by terrorist groups to target commercial aircraft throughout the world. On 28 November 2002, at Mombasa Kenya, terrorists fired two Soviet-made Strela-2 infrared-guided, Surface-to-Air Missiles (SAMs) at an Israeli-registered Arkia Airlines Boeing 757-300, carrying 261 passengers and 10 crewmembers as it departed for Israel.<sup>1</sup> Fortunately, the missiles failed to hit the aircraft and the airliner was able to continue on to Tel Aviv without further incident. While not the first time a civilian commercial aircraft has been fired upon using man-portable infrared missiles, this case represents the first incident where the attack has occurred outside of an established combat zone.<sup>2</sup> Unlike previous attacks, which attempted to contribute to regional military gains, the Mombasa attack was clearly politically motivated, and believed to have been carried out by terrorists with links to al Qaeda. This fact, coupled with the already heightened concerns over aviation security in the aftermath of the September 11, 2001 terrorist attacks, has made the shoulder-fired, infrared missile threat

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<sup>1</sup>David A. Kuhn, "Mombasa Attack Highlights Increasing MANPADS Threat," *Jane's Intelligence Review*, February 1, 2003: [journal on-line]; available from [http://www4.janes.com/subscribe/jir/doc\\_view.jsp](http://www4.janes.com/subscribe/jir/doc_view.jsp); Internet; accessed 4 February 2004.

<sup>2</sup>Robert E. Levin, *The Department of Homeland Security Needs to Fully Adopt a Knowledge-based Approach to Its Counter-MANPADS Development Program* (Washington, D.C.: General Accounting Office, GAO-04-341R, 30 January 2004).

a key issue for American homeland security.<sup>3</sup> The Mombasa incident represents a new dimension for international terrorism and has served as a wakeup call for American legislators to demand missile protection systems for American-registered commercial aircraft.

The Association of Old Crows (AOC), an American-based defence electronics organization, claims that over the past 25 years, there have been 35 confirmed attacks on civilian aircraft using man-portable, shoulder-fired surface-to-air missiles, resulting in the destruction of 24 aircraft and causing over 500 casualties.<sup>4</sup> Developed for infantry soldiers to defend against low-flying combat aircraft, man-portable air defence systems (MANPADS) have been employed by most military forces since the mid- to late-1960s. The AOC estimates that there are over 500,000 infrared-tracking MANPADS in circulation throughout the world today.<sup>5</sup> Once strictly limited to military forces, the number of MANPADS currently in the hands of terrorist groups ranges from 5,000 to 150,000, and the Mombassa attack demonstrates that these missiles can and will be used to target civilian aircraft.<sup>6</sup> Missile systems in the hands of terrorist organizations range from first-generation Soviet and American missiles to the most modern systems entering service with frontline military forces today. To combat this threat within the United States, Senator Barbara Boxer introduced legislation (S. 311 - The *Commercial Airline Missile Defense Act*) in the 108th Session of Congress, directing the Secretary of

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<sup>3</sup>United States, Congressional Research Services, *Homeland Security: Protecting Airliners from Terrorist Missiles* (Washington, D.C.: The Library of Congress, November 3, 2003), 10.

<sup>4</sup>AOC (The Electronic Warfare & Information Operations Association) Position Statement, *Missile Defense Systems for the American Commercial Airline Fleet*, (Alexandria, VA, 2003), 1.

<sup>5</sup>*Ibid.*

<sup>6</sup>United States, Congressional Research Services, *Homeland Security: Protecting Airliners...*, 4.

Transportation to issue regulations requiring airliners to be equipped with active missile defense systems.<sup>7</sup> The aim of the proposed legislation is to adapt existing military countermeasures technology to the civilian aviation sector, rather than developing independent systems for commercial aircraft protection.

Without question, terrorist groups targeting commercial air traffic with MANPADS would have a significant impact on the western world, affecting both the aerospace industry and the traveling public, yet legislating the use of active infrared missile protection systems is not the best solution. This paper will argue that, in the Global War on Terrorism, the legislating of active infrared missile countermeasures for commercial aircraft is an extremely costly, yet ineffective solution that does not guarantee protection from the MANPADS threat. The steps that will be followed to argue this assertion will be to describe the threat to aviation from shoulder-fired missiles, determine the risk from MANPADS, review the technology available to counter the threat, look at the proposed legislation to protect American-registered aircraft and discuss the cost associated with that legislation. Counter arguments for equipping civilian aircraft with defensive systems similar to those used by military combat aircraft will also be addressed. After demonstrating that the degree of protection provided by the proposed legislation does not justify its cost, this paper will then propose other measures that can provide a degree of protection without the high cost associated with equipping aircraft with active missile systems.

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<sup>7</sup>United States, Congressional Research Services, *Homeland Security: Protecting Airliners...*, 10. A copy of the proposed legislation, dated February 5, 2003, is attached as Annex A.

Shoulder-fired, heat-seeking infrared missiles were originally developed for infantry soldiers to target low-flying combat aircraft. Therefore, portability and ease of use under combat conditions were the over-riding design considerations and resulted in missiles with significant altitude and range limitations. However, commercial aircraft taking-off and landing are well within the engagement envelope of these systems. The threat to civil aviation is not restricted to just infrared-guided missiles, but includes systems employing command-line-of-sight guidance, laser-beam-guided systems, and anti-tank rocket propelled grenades (RPGs), which can also be used against low, slow-flying aircraft. The active countermeasures proposed under the *Commercial Airline Missile Defense Act* address only the infrared missile threat, and will be ineffective against these other missile systems.<sup>8</sup>

Cheap, simple, and effective, MANPADS are ideally suited to “rogue states” and terrorist organizations due to their portability and simplicity. Building upon the American Redeye system developed in the 1960s, the Soviets produced a family of increasingly effective and readily available systems. The Soviet Strela-2 (SA-7 'Grail'), Strela-3 (SA-14 'Gremlin'), Igla-1 (SA-16 'Gimlet') and Igla (SA-18 'Grouse') systems are considered easier to obtain than their American counterparts, yet a number of state-of-the-art U.S. Stinger systems, supplied to Afghanistan Mujahideen freedom-fighters during the 1980s are now considered to be in the hands of Osama bin Laden's al Qaeda

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<sup>8</sup>The *Commercial Airline Missile Defense Act*, S. 311, 108th Congress, February 5, 2003. [journal on-line]; available from <http://www.theorator.com/bills108/s311.html>; Internet; accessed 3 February 2004.

forces.<sup>9</sup> Fortunately, the most readily available systems are the least-capable, first generation Russian Strela-2s, which were used in the Mombasa attack. These short-range missiles have contact fuses, requiring a direct hit to detonate, are limited to rear hemisphere attacks only, and their tracking system is optimized for the very high exhaust temperatures associated with combat aircraft operating at high throttle settings.<sup>10</sup>

As the legislation proposed by Boxer is directed towards combating the threat from infrared missiles, this paper will focus on that type of guidance system. Tracking the infrared energy radiating from engines, air-conditioning units, and other aircraft heat-producing systems, infrared MANPADS have an effective range of about 5 kilometres, and about 13,000 feet in altitude.<sup>11</sup> Fortunately for civil aviation, analysis of MANPADS attacks indicate that not all attacks are successful in hitting the aircraft, and that aircraft, if hit, are not always destroyed. Under combat conditions, the Strela-2 system has a hit probability of only 19-25%, and these hits did not always correspond to a 'kill'.<sup>12</sup> Even the updated Strela-3 version, only boasts a 32% kill probability when operated by trained

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<sup>9</sup>The Strela-2 is also known as the 9K32 (Soviet designation), and the SA-7a Grail (NATO designation), along with the Strela-2M (Soviet 9K32M/NATO SA-7b Grail) and American Redeye systems are considered as first generation shoulder-fired, infrared-guided SAMs. The Strela-2 is the most available system and has been the weapon of choice for all attacks to date on commercial aircraft. Robert Sherman, "The Real Terrorist Missile Threat, and What Can be Done About It," *The Journal of the Federation of American Scientists* 56, no 3 (Autumn 2003): [journal on-line]; available from <http://www.fas.org/faspir/2003/v56n3/missile.htm>; Internet; accessed 3 February 2004.

<sup>10</sup>James C. O'Halloran, *Jane's Land-Based Air Defence*, 15th ed. (Surrey, UK: Sentinel House 2002), 26.

<sup>11</sup>For the purpose of this paper, distances will be expressed in kilometres (km), (1 km = 0.6214 miles, or 0.5400 nautical miles). Altitudes will be expressed in feet, as this is the conventional unit of measure for expressing altitude for flying operations (1 foot = 0.3048 metres).

<sup>12</sup>Michal Fiszer and Jerzy Gruszczynski, "On Arrows and Needles – Russia's Strela and Igla Portable Killers," *The Journal of Electronic Defence* (December, 2002): 46.



states willing to supply arms to terrorists.<sup>15</sup> Relatively inexpensive, shoulder-fired missile systems and their launchers can be obtained on the black market for as little as \$10,000 (US), making them highly attractive to terrorist groups.<sup>16</sup> Russian mafias have a well-established arms-for-drugs pipeline in place, and have demonstrated the ability to

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<sup>13</sup>Michael S. S. ... uszczynski, "On Arrows and Ne

obtain and supply virtually any type of weapons systems.<sup>17</sup> Well-funded terrorist groups, such as al Qaeda and Hamas, have ready access to virtually any desired weapon system and a training system to fully exploit its capabilities, therefore the use of MANPADS by terrorists to target Western airlines should not be ruled out.

Thomas Hunter in his article “The Proliferation of MANPADS” claims that Osama bin Laden and al Qaeda possess a number of SA-7s and Stinger weapons systems.<sup>18</sup> Further evidence to support this claim, and of the potential threat posed by bin Laden is provided by a training tape recovered in 2001 that provides detailed instruction and demonstrates the assembly and use of the Strela-2 system.<sup>19</sup> If this is true, then al Qaeda presents a significant threat to international civil aviation, and most notably U.S.-owned airlines. Yet, these missile systems do not always take down their intended target. Both the 2002 Mombasa attack, and a subsequent attack on a German DHL courier service Airbus departing from Baghdad International Airport in November 2003, demonstrate that MANPADS attacks are not always successful. In the case of the German DHL Airbus it was able to safely recover to the Baghdad airport after an infrared-guided missile struck its wing during departure.<sup>20</sup> All three crewmembers were unhurt.

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<sup>17</sup>Thomas B. Hunter, “The Proliferation of MANPADS,” *Jane’s Intelligence Review*, September 1, 2001; [journal on-line]; available from [http://www4.janes.com/subscribe/jir/doc\\_view.jsp](http://www4.janes.com/subscribe/jir/doc_view.jsp); Internet; accessed 4 February 2004.

<sup>18</sup>*Ibid.*

<sup>19</sup>David A. Kuhn, “Mombasa Attack Highlights...”

<sup>20</sup>Leslie Miller, “Three Companies Picked to Test Civilian Missile-Defense Systems,” *Associated Press*, January 7, 2004; [journal on-line]; available from <http://www.mindfully.org/Technology/2004/Anti-Missile-Commercial-Planes7jan04.htm>; Internet; accessed 23 January 2004.

According to James Loy, the Head of the U.S. Federal Transportation Security Administration, of the 24 successful attacks on civilian aircraft since 1978, the majority involved the targeting of propeller-driven aircraft.<sup>21</sup> Testifying before the House Aviation Sub-Committee, Loy further stated that of the six attacks that occurred on large, multiengine jets, five caused little or no damage.<sup>22</sup> Due to redundant engines, flight controls, electrical and fuel systems, modern commercial aircraft have demonstrated that MANPADS hits are survivable. With regard to the potential of a MANPADS attack within the United States, James Loy has stated that: "...according to intelligence reports, no credible threat of MANPADS being used by terrorists in the United States exists."<sup>23</sup> Therefore, while possible, the risk of downing a modern commercial aircraft with a MANPADS must be considered as low.

Man-portable missile systems pose a considerable threat to international civil aviation, yet they are not fail-safe, and measures can be taken to reduce their effectiveness even further. As the proposed legislation calls for adapting existing military equipment for civil aviation, a review of current military IR missile defence systems will follow. A number of infrared countermeasures systems are currently available for military and civilian aircraft. These include pyrotechnic flares, "safe flares", non-reflective paint that reduces an aircraft's infrared signature, changes in flight profiles during take-off and landing, and lasers that target and confuse the missile's

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<sup>21</sup>Toby Eckert, "Debate Grows Over Missile Defense for Airlines," *Copley News Service* (April 11, 2003) [journal on-line]; available from <http://www.globalsecurity.org/news/2003/030411-ailine-defense01.htm>; accessed 23 January 2004.

<sup>22</sup>*Ibid.*

<sup>23</sup>Admiral James Loy, speaking to foreign journalists on aviation security concerns, on 26 August 2003, Foreign Press Center, Washington, D.C. [journal on-line]; available from <http://usinfo.state.gov/topical/pol/conflict/03082609.htm>; Internet; accessed 3 February 2004.

infrared seeker.<sup>24</sup> Currently, military air forces use a number of systems to protect aircraft against MANPADS attacks that provide options for application to commercial aviation, and their potential will be evaluated against the perceived threat.

Pyrotechnic flares are used by military aircraft for protection against both surface-to-air and air-to-air infrared missiles, but the key to their success is the ability to detect an incoming missile and to release the flare at the appropriate time. Used in conjunction with aggressive manoeuvring, the aim is to have the missile transfer its tracking from the aircraft to that of the flare.<sup>25</sup> This countermeasure is unsuitable for airliners, as targeting the aircraft will occur when the aircraft is restricted in manoeuvrability, due to its high take-off weight and its low speed during the approach and landing phases of flight. The dispensing of pyrotechnic flares at low altitude over large urban areas surrounding major airports, would also most likely result in the setting of ground fires.<sup>26</sup> Additionally, unlike fighter-type aircraft, commercial passenger aircraft provide little chance for the pilot to visually acquire a missile approaching from the lower rear hemisphere, and would therefore be unaware of an inbound missile. Modern infrared-guided missiles, such as the American Stinger and Russian Igla, employ flare-rejection technology and are highly resistant to flare decoys, making flares ineffective against all but the oldest missiles.<sup>27</sup>

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<sup>24</sup>Robert Sherman, “The Real Terrorist Missile Threat...

<sup>25</sup>AOC (The Electronic Warfare & Information Operations Association) Position Statement, *Missile Defense Systems...*

<sup>26</sup>United States, Congressional Research Services, *Homeland Security: Protecting Airliners...*, 11.

<sup>27</sup>David A. Kuhn, “Mombasa Attack Highlights...

For these reasons, the use of flares to combat shoulder-fired, infrared missiles targeting civilian airliners is unacceptable.

A variation on the pyrotechnic flare concept is Israeli Industries' Flight Guard system, which dispenses charges of hot gases rather than burning solids to draw off the n commmsil.

Handwritten scribbles and the word "system" are visible at the bottom left corner of the page.

All aircraft operate well within the targeting envelope of shoulder-fired infrared missiles during the take-off and landing phases of a flight; phases when the aircraft are the least manoeuvrable. Combat aircraft departing from airports where the threat from surface-to-air missiles is present use the maximum power available to achieve their best climb rates, thus getting above the altitude envelope of the missile as quickly as possible. Also, instead of flying gentle approaches to the airport for landing, military aircraft remain above a missile's engagement altitude until the last moment, and then commence a spiraling descent to reduce the threat exposure time as much as possible. Neither of these procedures, directed towards minimizing exposure to the missile threat, is appropriate for commercial aircraft, as noise abatement procedures are in effect at most civilian airports to placate the surrounding population, while the need to sequence high numbers of approaching aircraft precludes the employment of spiral-type approaches. Military operations employing these tactics occur at hostile locations, with few aircraft approaching the airport simultaneously. Therefore, while changing the departure and arrival procedures around civilian airports could mitigate the danger from shoulder-fired missiles, these measures could also result in creating a situation more dangerous than the surface-to-air missile itself.

Laser countermeasures protection for aircraft is far superior to flares and other decoys to which many current MANPADS, including the Stinger, are highly resistant.<sup>31</sup> High value military aircraft, such as Air Force One and Two, and the American fleet of Airborne Warning and Control System (AWACS) aircraft employ active infrared countermeasures systems that detect, track and use a laser to disrupt the tracking circuits

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<sup>31</sup>David A. Kuhn, "Mombasa Attack Highlights..."

of incoming heat-seeking missiles. These systems are installed on approximately 150 American and British military aircraft, protecting at least 20 different fleets.<sup>32</sup> A number of American, British, Israeli, and Russian defence-based companies manufacture infrared countermeasure systems based on this concept for protecting valuable combat aircraft, and for aircraft involved in transporting government heads of state. Lockheed Martin Information Systems, BAE Systems North America, and Northrop Grumman Corporation are the primary contractors for these types of countermeasure in the United States. The effectiveness of these systems depends upon proper programming to detect and react to threats, and then regular verification and maintenance of the system to ensure its optimum performance. Within military units, engineers, specially trained in Electronic Warfare techniques, are responsible for programming, servicing and updating the systems based on the most current intelligence information available on the applicable threat system. Without the means to verify the system's functionality in a similar manner, defensive systems installed on airliners will be unable to provide a confident level of protection.

The most promising system currently available is based on 'Directed Infra-Red Countermeasures (DIRCM), which uses laser technology to confuse and disrupt the missile's tracking capability. The DIRCM concept combines a missile warning receiver system (MWS) to detect a missile launch and a laser to jam the guidance system of the missile. The United States Air Force's Large Aircraft Infra-Red Countermeasures (LAIRCM) system is often cited as the most likely technology that would be readily

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<sup>32</sup>Robert Sherman, "The Real Terrorist Missile Threat..."

converted to civilian application.<sup>33</sup> Manufactured by Northrop Grumman, the LAIRCM system provides protection for aircraft such as Air Force One and Air Force Two.<sup>34</sup> However capable, the cost and reliability of such complicated defensive systems make them unsuitable for wide use within the civil aviation industry. Testifying before the U.S. Senate Committee on Commerce, Science and Transportation, Stephan J. McHale, Deputy Administrator, Transportation Security Administration, stated:

The primary challenges to commercializing military IRCM equipment for application to civilian aircraft include: affordability in total cost of ownership; vastly improved reliability over their military counterparts; less labor [sic] and time-intensive maintenance interventions; lower false alarm rates; and countermeasures that are safely applied in operating environments of civilian aircraft.<sup>35</sup>

The Department of Homeland Security requires that any proposed system must have a Mean Time Between Failure (MTBF) reliability of at least 3,000 hours – 10 times the current rate for military DIRCM systems.<sup>36</sup> Compounding the future employment of these systems is an additional Department of Homeland Security requirement for a ‘call back notification system’ that would alert air traffic controllers that a missile launch had occurred.<sup>37</sup> Systems indicating a high number of false alarms could result in unnecessary

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<sup>33</sup>AOC (The Electronic Warfare & Information Operations Association) Position Statement, *Missile Defense Systems...*, 2.

<sup>34</sup>Robert Sherman, “The Real Terrorist Missile Threat...

<sup>35</sup>Stephen McHale, Deputy Administrator, Transportation Security Administration, testifying before the U.S. Senate Committee on Commerce, Science, & Transportation, on 5 November 2003, Washington, D.C. [journal on-line]; available from <http://usinfo.state.gov/topical/pol/terror/texts/03110502.ht>; Internet; accessed 3 February 2004.

<sup>36</sup>Robert E. Levin, *The Department of Homeland Security Needs to...*

<sup>37</sup>*Ibid.*



airport closures, and therefore before such systems can be installed in commercial aircraft the excessive false alarm rates must be overcome.

High-bypass engines of modern commercial jet engines produce less heat than military fighter aircraft engines at high thrust levels, and may have contributed to the failure of the Mombasa attack.<sup>38</sup> This reduction in temperature results in a shift to higher wavelength of the emitted infrared energy, and in some cases is enough to degrade the acquisition range and tracking ability of the older Strela missiles. The infrared seeker system is designed to acquire and track specific wavelengths of infrared radiation that correspond to the engine temperatures of combat aircraft.<sup>39</sup> As the radiant temperature increases, its corresponding infrared wavelength decreases according to *Wein's Law* ( $\lambda = U/T$ ).<sup>40</sup> Older systems, such as the Strela-2 were designed with primitive, non-cooled seekers optimized to track heat sources with wavelengths of 1.5  $\mu\text{m}$ , or engine temperatures operating the region of 1600° C<sup>41</sup>. At lower operating temperatures, the wavelength increases, and the missile's acquisition range and tracking efficiency decrease. Thus, the reduction in operating temperatures of modern commercial aircraft engines already provides a degree of protection from the older, first-generation, shoulder-fired infrared missiles most likely to be in the possession of terrorist organizations.

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<sup>38</sup>Filippo Neri, *Introduction to Electronic Defense Systems*, 2d ed. (Boston: Artech House, 2001), 208.

<sup>39</sup>*Ibid.*, 196.

<sup>40</sup>Wein's Law states that the wavelength for maximum radiant emittance is inversely proportional to the temperature, where  $\lambda$  is the wavelength in micrometres, U is a constant (2898 [ $\mu\text{mK}$ ]), and T is the absolute temperature of the heat source. Filippo Neri, *Introduction to Electronic Defense...*, 200-201.

<sup>41</sup>James C. O'Halloran, *Jane's Land-Based...*, 26.

Although unsuccessful, the November 2002 MANPADS attack on the Arkia airliner has raised concerns throughout the world to the potential use of surface-to-air missiles by terrorist organizations. Following the incident, legislation was introduced in the United States Congress on February 5, 2003, to safeguard against future attacks on American aircraft.<sup>42</sup> The *Commercial Airline Missile Defense Act*, proposed by Senator Barbara Boxer (D – CA), would require all civilian commercial aircraft to carry missile protection devices similar to systems currently used by military transport aircraft. “Shoulder-fired missiles are a serious threat to our airlines, our economy, and the personal safety of every American airline passenger,” Boxer said. “This is a relatively small cost to address a very big threat. We have a proven technology to counter that threat and we can take a giant step forward in the defense of our homeland.”<sup>43</sup> If passed, the *Commercial Airline Missile Defense Act* would direct the Secretary of Transportation to purchase and make available missile defence systems for all currently in-service and on-order, turbojet aircraft.<sup>44</sup> The bill also calls for all future aircraft to be equipped with countermeasure systems to be funded by the individual airlines.<sup>45</sup>

Estimates for installing Directed Infrared Countermeasures on commercial aircraft range from \$2-3 million per aircraft, and these numbers do not take into account the regular servicing costs, nor the loss in revenue due to the downtime required for system

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<sup>42</sup>Robert Longley, “Bill Would Add Missile Defense to Airliners,” *U.S. Government Information/Resources*, (February 18, 2003) [journal on-line]; available from <http://usgovinfo.about.com/library/weekly/aa021803a.htm>; Internet, accessed 23 January 2004.

<sup>43</sup>*Ibid.*

<sup>44</sup> *The Commercial Airline Missile Defense Act...*

<sup>45</sup> Robert Longley, “Bill Would Add Missile...

installation.<sup>46</sup> Congressional analysts place the cost to taxpayers for installing operational infrared missile defence systems on the current U.S. fleet of over 6,600 commercial jet liners at from \$7 to \$10 billion.<sup>47</sup> The Air Transport Association, which represents the American Airline industry, says total costs could reach as high as \$100 billion when life-cycle costs are included.<sup>48</sup> Airlines would be responsible for all ongoing maintenance costs, as well as for the costs incurred in obtaining systems for aircraft acquired after the legislation is passed. Representatives from international airlines are concerned that the cost of installing the required countermeasures far outweighs any risk of being attacked. “Given the financial state of the airline industry at the moment, the likelihood of the airlines being able to fund that sort of technology is pretty slim,” said Chris Yates, aviation security editor for Jane’s, a defense information firm. “You would have to look at government funding yet again.”<sup>49</sup> Considering the fragile financial state of most airline companies today, without governments funding the mandated systems, the need to retrofit existing aircraft with missile defence equipment would most likely lead to the demise of a number of airlines.

The Americans are not alone when it comes to worrying about the threat from shoulder-fired, surface-to-air missiles. Following an unsuccessful attack by the Palestinian terrorist group Black September on an Israeli El Al aircraft departing from Rome in 1973, the airline fitted its entire Boeing 707 fleet with U.S.-made

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<sup>46</sup>David A. Kuhn, “Mombasa Attack Highlights...

<sup>47</sup>Robert Longley, “Bill Would Add Missile...

<sup>48</sup>Dave Montgomery, “Missile Defense in Works for Airliners,” *The Wichita Eagle*, 18 January 2004: [journal on-line]: available from <http://www.kansas.com/mld/kansas/business/7736176.htm>; Internet; accessed 23 January 2004.

<sup>49</sup>Toby Eckert, "Debate Grows Over Missile...

countermeasures systems. These systems were removed shortly thereafter due to poor performance and the effects of the equipment on the aircraft's electrical system.<sup>50</sup> After the Mombasa attack, the Israeli Defence Minister, Shaul Mofaz called for his government to provide \$40 million to equip 30 passenger aircraft with IR missile countermeasure systems.<sup>51</sup> Two Israeli defence contractors, Rafael and Israeli Aircraft Industries (IAI) are proposing to modify their military systems for the commercial aircraft. Rafael's approach will be based on DIRCM technology, while the IAI system will use its Flight Guard "safe flare" system.

With two confirmed attacks against its commercial airlines, Israel may be justified in equipping its small fleet of passenger aircraft, yet there has never been a documented attempt to target an American aircraft under similar conditions. According to Federal Aviation Administration estimates there will be about 5,575 passenger jet aircraft, and an additional 1,082 all-cargo jet deployed in air carrier operations in 2004.<sup>52</sup> While, the MANPADS threat to the Department of Homeland Security may be a 'concern', American intelligence sources report that no 'credible' threat from these systems exist within the United States.<sup>53</sup> Therefore, the cost of the *Commercial Airline Missile Defense Act*, mandating the installation of infrared missile defence systems onboard the nation's entire fleet of commercial aircraft, cannot be justified by the unsuccessful 2002 Mombasa attack on the Arkia aircraft.

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<sup>50</sup>David Learmount and others, "War on Terror, Can Countermeasures Work?" *Flight International*, December 10-16, 2002: 16.

<sup>51</sup>*Ibid.*, 14.

<sup>52</sup>United States, Congressional Research Services, *Homeland Security: Protecting Airliners...*, 10.

<sup>53</sup>Admiral James Loy, speaking to foreign journalists on aviation...

For many within the United States the 2002 Mombasa MANPADS attack was a wake up call, highlighting a new dimension in international terrorism. This attack demonstrated that: the use of MANPADS is no longer restricted to combat zones; MANPADS are in the hands of terrorist groups such as al Qaeda; and, that terrorist organizations are willing to target civilian aircraft in this manner to further their causes.<sup>54</sup> Whether or not an attack on an American commercial airliner succeeds in destroying the aircraft, the effects of such an attack could be devastating to the American aviation industry and the traveling public. Although the grounding of aircraft following September 11, 2001, was only of limited duration, the aviation industry lost billions of dollars, as did other air-travel-dependent industries, such as tourism.<sup>55</sup> With technology available to counter the threat, albeit at a cost of upwards of \$3 million per aircraft, can Americans not afford to proceed with these measures?

Unlike the situation after the September 11 attacks, should a MANPADS attack occur, there are few confidence-building security improvements that could be implemented quickly to again restore confidence in the security of the civil aviation system.<sup>56</sup> Yet, the spending of billions of dollars does not guarantee 100 percent protection either from infrared MANPADS, or from other systems that may be used to target aircraft during the departure and arrival phases of flight. Available Infrared Countermeasure systems may provide a degree of protection against the older SA-7 and SA-14 systems, but their effectiveness decreases significantly with the newer generation

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<sup>54</sup>David A. Kuhn, "Mombasa Attack Highlights..."

<sup>55</sup>Paul J. Caffera, "The Vexing Problem of Protecting Airliners from MANPADS," *Aircraft Survivability* (Spring, 2003): 14.

<sup>56</sup>*Ibid.*

of missiles. During NATO's 1999 Allied Force Operation in Kosovo, an American F-16 was shot down by an infrared-guided Igla or Igla-1 missile, even though it was equipped with a frontline military missile countermeasures system.<sup>57</sup> Therefore the presence of a missile defence system does not guarantee immunity from a missile attack, and the failure of defence systems to protect civil aircraft against MANPADS could completely destroy public confidence in their lawmakers, police forces and, indeed, the defence experts within the aviation industry.

The danger posed by MANPADS is not new. The threat of shoulder-fired missiles targeting commercial aircraft has existed since these missile systems were first developed and fielded. However, the U.S. government is now taking the threat of missile attacks against commercial passenger jets more seriously since the al Qaeda attempted downing of the Israeli Boeing 757 in Kenya, and that is how it should be. But a snap decision, such as the *Commercial Airline Missile Defense Act*, should not be made on what to do about it.

No single countermeasure can shield all airliners from all shoulder-fired, infrared-guided, surface-to-air missiles under all conditions. Solutions to the threat will have to consist of a number of activities that address: susceptibility reduction (measures designed to prevent MANPADS hits), vulnerability reduction (improving aircraft survivability in the event of a MANPADS strike), and non-proliferation (preventing the acquisition and use of MANPADS by problematic end-users). Measures required to reduce susceptibility include: improving airport perimeter security measures along arrival and departure paths, modifying noise abatement procedures as much as possible to enable departing aircraft to

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<sup>57</sup>Michal Fiszer and Jerzy Gruszczynski, "On Arrows and Needles...", 51.

get above the effective altitude of the missile as quickly as possible, and the use of infrared-signature-reducing paints. Infrared suppression paint appears to offer few complications for airline application compared to other potential countermeasures, and this measure is the quickest fix for the airlines to adapt.<sup>58</sup>

Combat operations such as Desert Storm provide an opportunity to observe how various aircraft designs can contribute to their survivability, should they be struck by infrared missiles, and thus illustrate steps that can be taken to reduce an aircraft's vulnerability to an attack. During Desert Storm four U.S. Marine, twin-engine F/A-18 Hornets were hit by MANPADS and all four were able to safely recover to their bases without injury to their pilots.<sup>59</sup> In contrast to this record, four Marine, single-engine AV-8B Harrier aircraft were hit, and all four were destroyed.<sup>60</sup> The main design differences, apart from the Hornet's twin-engines, included keeping flight controls as far away as possible from engines, separating fuel systems from likely hit locations, incorporating fuel shutoff controls for the aft portion of engines, and using extended nozzles (that may be sacrificed in the event of a hit).<sup>61</sup> Other techniques that should be incorporated in future aircraft design are improved fire and explosion suppression systems, redundancy and separation of flight controls and hydraulic systems, developing engine rotors capable of rebalancing after sustaining damage, and ensure the hardening of vital areas that are vulnerable to external threats. Pilots can also aid in foiling a missile's targeting by using

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<sup>58</sup>United States, Congressional Research Services, *Homeland Security: Protecting Airliners...*, 12.

<sup>59</sup>Michael Meyers, "Tactical Aircraft Survivability Against the MANPADS Threat," *Aircraft Survivability* (Summer, 1999): 23.

<sup>60</sup>*Ibid.*

<sup>61</sup>Greg Czarnecki, "National MANPADS Workshop A Vulnerability Perspective", *Aircraft Survivability* (Summer, 1999): 10.

techniques such as thermally managing engines by having outboard engines run hotter than inboard engines, which may cause an incoming infrared missile to target outboard engines instead of inboards, thereby reducing the potential for cabin decompression, wing fires and wing-structure failures.

Lastly, non-proliferation efforts must be taken to prevent these portable systems from getting into the hands of terrorist groups. Surplus stocks of older systems should be destroyed, while safeguards, such as fire control features, should be incorporated into all future systems.

Since September 11, 2001, Americans have had every reason to take their security concerns as seriously as possible. As well, the 2002 Mombasa terrorist MANPADS attack on the Arkia aircraft could be an indicator of an emerging threat, yet installing missile defence systems on every U.S.-registered aircraft is not the most effective means of targeting the threat. Senator Barbara Boxer's *Commercial Airline Missile Defense Act*, calling for active infrared missile protection, attempts to safeguard American commercial aircraft from attacks by terrorists employing shoulder-fired, infrared tracking surface-to-air missiles. Yet the proposed legislation does not account for non-infrared-guided, short range missiles and rocket propelled grenades that may also be used to down an airliner within the operating environment of an airport, because it is too restrictive in defining the potential threat. Countermeasures providing security against IR missiles target the missile's seeker system and are ineffective against missiles utilizing other guidance systems. The only significant contribution this legislation provides against command-line-of-sight, laser-beam-guided missiles, and anti-tank rocket propelled grenades, is missile launch detection and warning. The IR countermeasures system is unable to



disrupt the guidance circuits of these later systems, because they do not rely on IR energy to track their intended target.

A combination of measures must be taken to reduce an aircraft's susceptibility from a missile attack. These actions include increasing airport perimeter security efforts, changing air traffic control procedures to minimize aircraft exposure to the MANPADS threat, and lastly to employ IR suppression techniques, such as using infrared signature reducing paints. Design modifications to new and existing aircraft can contribute to reducing the vulnerability to missile strikes in the vicinity of engines and other heat producing areas. Redundancy of engines, fuel and flight control systems have proven their worth in combat operations, and these features need to be incorporated into commercial aircraft. Finally, governments and militaries must increase their efforts to prevent the proliferation of weapon systems by terrorist groups.

History has shown that not all shoulder-fired, infrared missile attacks succeed in hitting their intended target, and that even if hit, the strike is not always fatal. Even James Loy, Head of the Federal Transportation Security Administration, acknowledged that of the six attacks that occurred on large, multiengine jets, five caused little or no damage.<sup>62</sup> Conversely, the loss of the American F-16 fighter in Kosovo shows that even military aircraft, equipped with the latest, state-of-the-art countermeasure systems are being downed by infrared surface-to-air missiles. Therefore, in the absence of a credible threat to its aircraft, the cost of spending \$10 billion dollars on a defence system for commercial aircraft as called for in the *Commercial Airline Missile Defense Act*, and which will only provide limited protection to American citizens, cannot be justified.

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<sup>62</sup>Toby Eckert, "Debate Grows Over Missile..."

*Annex A – The Commercial Airline Missile Defense Act*

108th CONGRESS  
1st Session

**S. 311**

To direct the Secretary of Transportation to issue regulations requiring turbojet aircraft of air carriers to be equipped with missile defense systems, and for other purposes.

**IN THE SENATE OF THE UNITED STATES**

**February 5, 2003**

Mrs. Boxer (for herself and Mr. Schumer) introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

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**A BILL**

To direct the Secretary of Transportation to issue regulations requiring turbojet aircraft of air carriers to be equipped with missile defense systems, and for other purposes.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

**SECTION 1. SHORT TITLE.**

This Act may be cited as the 'Commercial Airline Missile Defense Act'.

**SEC. 2. REGULATIONS REQUIRING MISSILE DEFENSE SYSTEMS.**

(a) IN GENERAL- Not later than 90 days after the date of enactment of this Act, the Secretary of Transportation shall issue regulations that require all turbojet aircraft used by an air carrier for scheduled air service to be equipped with a missile defense system.

(b) SCHEDULE FOR INSTALLATION- The regulations shall establish a schedule for the purchase and installation of such systems on turbojet aircraft currently in service and turbojet aircraft contracted for before the date of issuance of the regulations.

(c) NEW AIRCRAFT- The regulations shall also require that all turbojet aircraft contracted for on or after the date of issuance of the regulations by an air carrier for scheduled air service be equipped with a missile defense system.

(d) DEADLINES FOR COMMENCEMENT OF INSTALLATION- The regulations shall require that installation and operation of missile defense systems under the regulations begin no later than December 31, 2003.

### **SEC. 3. PURCHASE OF MISSILE DEFENSE SYSTEMS BY THE SECRETARY.**

The Secretary of Transportation shall purchase and make available to an air carrier such missile defense systems as may be necessary for the air carrier to comply with the regulations issued under section 2 (other than subsection (c)) with respect to turbojet aircraft used by the air carrier for scheduled air service.

### **SEC. 4. RESPONSIBILITY OF AIR CARRIER.**

Under the regulations issued under section 2, an air carrier shall be responsible for installing and operating a missile defense system purchased and made available by the Secretary of Transportation under section 3.

### **SEC. 5. PROGRESS REPORTS.**

Not later than January 1, 2004, and each July 1 and January 1 thereafter, the Secretary of Transportation shall transmit to Congress a report on the progress being made in implementation of this Act, including the regulations issued to carry out this Act.

### **SEC. 6. INTERIM SECURITY MEASURES**

(a) IN GENERAL- In order to provide interim security before the deployment of missile defense systems for turbojet aircraft required under section 2, the President shall--

- (1) exercise the President's authority under title 32, United States Code, to elevate National Guard units to Federal status for the purpose of patrolling areas surrounding airports to protect against the threat posed by missiles and other ordnance to commercial aircraft; and

(2) deploy units of the United States Coast Guard, in coordination with the Secretary of Transportation and the Secretary of Homeland Security, for the purpose of patrolling areas surrounding airports to protect against the threat posed by missiles and other ordnance to commercial aircraft.

(b) PROGRESS REPORT- Not later than 90 days after the date of enactment of this Act, the President shall submit to Congress a report on the progress being made to implement this section.

## **SEC. 7. DEFINITIONS.**

In this Act, the following definitions apply:

(1) AIRCRAFT AND AIR CARRIER- The terms 'aircraft' and 'air carrier' have the meaning such terms have under section 40102 of title 49, United States Code.

(2) MISSILE DEFENSE SYSTEM- The term 'missile defense system' means an appropriate (as certified by the Secretary of Transportation) electronic system that would automatically--

(A) identify when the aircraft is threatened by an incoming missile or other ordnance;

(B) detect the source of the threat; and

(C) disrupt the guidance system of the incoming missile or other ordnance, which is intended to result in the incoming missile or other ordnance being diverted off course and missing the aircraft.

## Bibliography

- AOC (The Electronic Warfare & Information Operations Association) Position Statement. *Missile Defense Systems for the American Commercial Airline Fleet*. Alexandria, VA, 2003.
- Caffera, Paul J. "Hand-held Terror," *Washington Post*, 5 November 2001. Journal on-line; available from [http://www.crows.org/Government%20Affairs/Legislation/ManPADS/washpost\\_handheld.pdf](http://www.crows.org/Government%20Affairs/Legislation/ManPADS/washpost_handheld.pdf); Internet; accessed 3 February 2004.
- Caffera, Paul J. "The Vexing Problem of Protecting Airliners from MANPADS," *Aircraft Survivability* (Spring, 2003): 13-16.
- The *Commercial Airline Missile Defense Act*, S. 311, 108th Congress, February 5, 2003. Journal on-line; available from <http://www.theorator.com/bills108/s311.html>; Internet; accessed 3 February 2004.
- Czarnecki, Greg. "National MANPADS Workshop A Vulnerability Perspective." *Aircraft Survivability* (Summer, 1999): 10-11.
- Eckert, Toby. "Debate Grows Over Missile Defense for Airliners." *Copley News Service* (April 11, 2003). Journal on-line; available from <http://www.globalsecurity.org/news/2003/030411-ailine-defense01.htm>; accessed 23 January 2004.
- Fiszer, Michal and Jerzy Gruszczynski. "On Arrows and Needles – Russia's Strela and Iгла Portable Killers." *The Journal of Electronic Defense* (December 2002): 46-52.
- Hunter, Thomas B. "The Proliferation of MANPADS." *Jane's Intelligence Review*, September 1, 2001. Journal on-line; available from [http://www4.janes.com/subscribe/jir/doc\\_view.jsp](http://www4.janes.com/subscribe/jir/doc_view.jsp); Internet; accessed 4 February 2004.
- Kuhn, David A. "Mombasa Attack Highlights Increasing MANPADS Threat," *Jane's Intelligence Review*, February 1, 2003. Journal on-line; available from [http://www4.janes.com/subscribe/jir/doc\\_view.jsp](http://www4.janes.com/subscribe/jir/doc_view.jsp); Internet; accessed 4 February 2004.
- Learmount, David, Murdo Morrison, Graham Warwick, Arie Egozi, and Vladimir Karnazov. "War on Terror, Can Countermeasures Work?" *Flight International*. December 10-16, 2002: 14-16.
- Levin, Robert E. *The Department of Homeland Security Needs to Fully Adopt a Knowledge-based Approach to Its Counter-MANPADS Development Program*. Washington, D.C.: General Accounting Office, GAO-04-341R, 30 January 2004.

- Longley, Robert. "Bill Would Add Missile Defense to Airliners." *U.S. Government Information/Resources* (February 18, 2003). Journal on-line; available from <http://usgovinfo.about.com/library/weekly/aa021803a.htm>; Internet, accessed 23 January 2004.
- Loy, Admiral James. Speaking to foreign journalists on aviation security concerns, on 26 August 2003. Foreign Press Center, Washington, D.C. Journal on-line; available from <http://usinfo.state.gov/topical/pol/conflict/03082609.htm>; Internet; accessed 3 February 2004.
- McHale, Stephen. Deputy Administrator, Transportation Security Administration, testifying before the U.S. Senate Committee on Commerce, Science, & Transportation, on 5 November 2003, Washington, D.C.. Journal on-line; available from <http://usinfo.state.gov/topical/pol/terror/texts/03110502.ht>; Internet; accessed 3 February 2004.
- Meyers, Michael, "Tactical Aircraft Survivability Against the MANPADS Threat." *Aircraft Survivability* (Summer, 1999): 22-23.
- Miller, Leslie. "Three Companies Picked to Test Civilian Missile-Defense Systems." *Associated Press*, January 7, 2004. Journal on-line; available from <http://www.mindfully.org/Technology/2004/Anti-Missile-Commercial-Planes7jan04.htm>; Internet; accessed 23 January 2004.
- Montgomery, Dave. "Missile Defense in Works for Airliners." *The Wichita Eagle*. 18 January 2004. Journal on-line: available from <http://www.kansas.com/mld/kansas/business/7736176.htm>; Internet; accessed 23 January 2004.
- Neri, Filippo. *Introduction to Electronic Defense Systems*, 2d ed. Boston: Artech House, 2001.
- O'Halloran, James C. *Jane's Land-Based Air Defence*. 15<sup>th</sup> ed. Surrey, UK: Sentinel House, 2002.
- Sherman, Robert. "The Real Terrorist Missile Threat, and What Can be Done About It." *The Journal of the Federation of American Scientists* 56, no 3 (Autumn 2003). Journal on-line; available from <http://www.fas.org/faspir/2003/v56n3/missile.htm>; Internet; accessed 3 February 2004.
- United States. Congressional Research Services. *Homeland Security: Protecting Airliners from Terrorist Missiles*. Washington, D.C.: The Library of Congress, November 3, 2003.

Venter, Al J. "SAMs – The Ultimate Terror Threat." *Jane's Terrorism & Security Monitor* (October 1, 2003). Journal on-line; available from <http://www4.janes.com/K2/docprint.jsp>; Internet; accessed 8 March 2004.