MANPADs Threat to Commercial Aviation

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Christopher Bolkcom, Bart Elias, Andrew Feickert
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Outline

- Bottom Line
- Threat
- Mitigation Options
- Summary
Bottom Line

Threat
- MANPADS are cheap, widely proliferated, easy to use and conceal, and potentially lethal to all classes of aircraft

Mitigation Options
- No single-point solution
- Menu of options which are situationally driven
Threat: Types/Capabilities

- Three Basic Types
  - Infrared (IR) – Stinger (US), SA-18 (Russia)
  - Command Line-of-Sight (CLOS) – Blowpipe, Javelin (UK)
  - Laser Beam Riders – RBS-70 (Sweden), Starstreak (UK)

- General Capabilities
  - Portable, reliable, inexpensive, and fairly easy to use
  - Target detection range about 6 miles
  - Engagement range about 4 miles
  - Aircraft above 20,000 feet relatively safe
  - Take off and landing = most vulnerable to attack
  - Large engagement footprint = difficult to detect on the ground
MANPAD Configuration

- Launch Tube
- Gripstock
- Battery
- Motor
- Warhead
- Seeker

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Threat: Proliferation

- Estimates of Military Inventories – 350,000 to 500,000
- Non-State Actors – 5,000 to 150,000
  - 25 to 30 groups (IRA, FARC, Hezbollah, PKK)
  - Reported missiles
    - Stingers = IR
    - SA-7s = IR
    - SA-14/16/18s = IR
    - HN-5/QW-1 (China) = IR
    - Blowpipe = CLOS
- Reports of Missiles in Circulation
  - “5,592 missiles captured in Afghanistan as of December 2002”
  - “4,000 to 5,000 available to Iraqi insurgents”
History of Use - Military Experience

- Vietnam
  - Low PK, but lots of shots
- Afghanistan
  - Turned the tide for Mujahadeen
- Post-Cold War
  - IR guided SAMs were the primary source of air combat losses in Operation Desert Storm
  - Since 1973, nearly half of all air losses in combat have been attributed to IR-guided SAMs, many of them SFM
  - Others estimate that SFMs caused 90% of worldwide combat aircraft losses from 1984-2001.
History of Use - Civilian Attacks

- Most widely reported statistic - over the past 25 years:
  - 35 aircraft attacked
  - 24 shot down
  - Resulting in more than 500 fatalities
  - Majority of these attacks occurred in war zones
- First reported incident
  - 01/73 Rome, Italy *Black September* smuggles 14 SA-7's into Italy
    Caught as Israeli PM Meir’s plane targeted

- CRS Research
  - Six incidents where large turbojet civilian aircraft attacked by shoulder-fired missiles
## Civilian Attacks

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Aircraft</th>
<th>Operator</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-Nov-1983</td>
<td>Angola</td>
<td>Boeing 737</td>
<td>Angolan Airlines (TAAG)</td>
<td><strong>Catastrophic:</strong> 130 fatalities of 130 people on board</td>
</tr>
<tr>
<td>9-Feb-1984</td>
<td>Angola</td>
<td>Boeing 737</td>
<td>Angolan Airlines (TAAG)</td>
<td><strong>Hull Loss:</strong> aircraft overran runway on landing after being struck by a missile at 8,000 ft during climbout. No fatalities with 130 on board.</td>
</tr>
<tr>
<td>21-Sep-1984</td>
<td>Afghanistan</td>
<td>DC-10</td>
<td>Ariana Afghan Airlines</td>
<td><strong>Substantial Damage:</strong> Aircraft damaged by the missile, including damage to two hydraulic systems, landed safely. No fatalities.</td>
</tr>
<tr>
<td>10-Oct-1998</td>
<td>D.R. of Congo</td>
<td>Boeing 727</td>
<td>Congo Airlines</td>
<td><strong>Catastrophic:</strong> 41 fatalities of 41</td>
</tr>
<tr>
<td>19-Nov-2002</td>
<td>Kenya</td>
<td>Boeing 767</td>
<td>Arkia Israeli Airlines</td>
<td><strong>Miss:</strong> Two SA-7’s fired during climbout, but missed. No fatalities.</td>
</tr>
<tr>
<td>22-Nov-2003</td>
<td>Baghdad</td>
<td>A300</td>
<td>DHL</td>
<td>SA-7 hit left engine. Set the left wing on fire. Landed safely due to superb flying.</td>
</tr>
</tbody>
</table>
Vulnerability of Civil Aircraft
Mitigation Option: Flight Procedures

- Limited Options, Significant Operational Constraints

<table>
<thead>
<tr>
<th>OPTION</th>
<th>CONSIDERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steep Climbouts, Spiral Descents</td>
<td>Aircraft performance</td>
</tr>
<tr>
<td></td>
<td>Operational cost</td>
</tr>
<tr>
<td></td>
<td>ATC and pilot workload</td>
</tr>
<tr>
<td></td>
<td>Airspace congestion</td>
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<tr>
<td></td>
<td>Passenger comfort</td>
</tr>
<tr>
<td></td>
<td>Safety</td>
</tr>
<tr>
<td></td>
<td>Won’t eliminate threat close to airport</td>
</tr>
<tr>
<td>Varied Approach and Departure Paths</td>
<td>ATC and pilot workload</td>
</tr>
<tr>
<td></td>
<td>Non-secure radio communications</td>
</tr>
<tr>
<td></td>
<td>Published procedures</td>
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<td></td>
<td>Access to near real-time flight data</td>
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</table>
Mitigation Option: Flight Procedures

<table>
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<th>OPTION</th>
<th>CONSIDERATIONS</th>
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<tbody>
<tr>
<td>Night Flights/No Lights</td>
<td>Schedule based on passenger demand</td>
</tr>
<tr>
<td></td>
<td>Airport capacity and noise</td>
</tr>
<tr>
<td></td>
<td>Safety requirements</td>
</tr>
<tr>
<td>Over Water Approaches and Departures</td>
<td>Limited applicability to airports near large bodies of water</td>
</tr>
<tr>
<td></td>
<td>Already implemented for noise abatement at some airports</td>
</tr>
<tr>
<td></td>
<td>Of limited benefit unless combined with maritime patrols to protect waters</td>
</tr>
<tr>
<td></td>
<td>under flight paths</td>
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</tbody>
</table>
Mitigation Option: Pilot Training

- Pilots already experience a wide variety of scenarios in the simulator
- Additional benefit of missile strikes scenarios needs to be assessed
- Evasive maneuvering is not advised

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<th>OPTION</th>
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<tr>
<td>Specific Missile Strike Scenarios</td>
<td>Similarity to other in-flight emergencies</td>
</tr>
<tr>
<td></td>
<td>Large number of possible post attack failure scenarios</td>
</tr>
<tr>
<td>Evasive Maneuvers Training</td>
<td>Missile detection capability</td>
</tr>
<tr>
<td></td>
<td>Response time</td>
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<tr>
<td></td>
<td>Aircraft performance</td>
</tr>
<tr>
<td></td>
<td>Aircraft structural integrity</td>
</tr>
<tr>
<td></td>
<td>Loss of control</td>
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</tbody>
</table>
Mitigation Option: Aircraft Hardening

- Civil aviation survivability research has focused on internal bomb blasts
  - Program established in response to the Pan Am 103 bombing
  - Hardened cargo liners and containers

- Survivability characteristics of large transport aircraft from missile strikes is largely unknown
  - Service history: 24/35, P(k) = 69%, but this represents a wide variety of aircraft types (props, helicopters, business jets, and large jets)
  - Five large jets have come under attack, two were destroyed
  - Military research and testing of limited applicability to the civilian domain
Mitigation Option: Aircraft Hardening

Options under consideration
- Structural hardening
- Isolating independent hydraulic and flight control systems
- Improved fire suppression
- Fuel tank inerting
- Adaptive flight controls/Aircraft health monitoring

Considerations:
- Safety benefits
  - These options may protect aircraft against system failures as well
- Long range mitigation strategy
  - May be applied to new type designs in the future
  - Replacement rate and introduction of new aircraft types is relatively low
  - Retrofitting is likely to be costly and may be technically infeasible or economically impractical
- Hardening that increases aircraft weight may significantly increase operational costs
Mitigation Option: Airport Security

- Threat assessments
  - Examine airport layout, flight paths to identify specific vulnerabilities
    - Large U.S. airports
    - Selected foreign airports
      - Bangkok, Thailand – APEC Summit in October 2003
      - Athens, Greece – 2004 Olympics
Mitigation Option: Airport Security

- Deploying security forces – increased patrols
  - Coast Guard and National Guard
  - Federal and local law enforcement
  - “Neighborhood Watch” type programs
- Considerations:
  - Other Homeland Security concerns
  - Very large areas to protect
    - Hundreds of square miles around every airport

- Surveillance technology
  - Forward looking infrared – aerial patrols
  - Ground radar
  - Cameras and remote sensors
Mitigation Option: Flares

- Pyrotechnic decoys
- Considerations
  - Mature technology
  - Relatively cheap
  - Omni directional
  - Can be used preemptively
  - Safety
  - More difficult to spoof latest generation seekers
  - Pyrophoric flares in development that are safer and more effective vs discriminating two-color missile threats

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Mitigation Option: Directed IR Countermeasures (DIRCM)

- **Directed laser, “blinds” IR-guided missile**

- **Considerations**
  - Very powerful jammer
  - Effective against all classes of IR-guided threats
  - Relatively expensive: $1 - 3 million per aircraft / 6,000 aircraft
  - Just being fielded in the military
  - Can’t be used pre-emptively
  - Effective missile approach warning system (MAWs) is crucial
  - No effect on CLOS or Laser beam riding MANPADs
Mitigation Option: IR Countermeasures (IRCM)

- Lamp- or lantern-based heat source “blinds” IR-guided missile

- Considerations
  - Fielded on numerous helicopters and some fixed wing aircraft
  - Omni-directional, continuous operation
  - Weaker J/S than DIRCM
  - Placement relative to engine important
  - No effect on CLOS or laser beam riding MANPADs
Mitigation Option: Airport Active Defense

- Airport-based flares, IRCMs, active defenses, escort aircraft (or aerostat?) equipped with DI RCM (E-DI RCM)

- Considerations
  - Protects all aircraft, not just U.S. carriers
  - Limited footprint
  - Fratricide (HUMRAAM)
  - Technological maturity (THEL)
  - J/S ratio over large area (lamp based IRCMs)
  - Airspace control (E-DI RCM)

25 rocket intercepts

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Mitigation Option: “Camouflage”

- Reduce the aircraft’s EO/IR reflectivity and emissivity
  - Suppress engine IR signature (duct turning, shrouds, thermal barriers)
  - Use neutral, flat paints and/or low-IR paint

- Considerations
  - Entirely passive
  - Synergy potential: can be used in conjunction with IRCMs and other options
  - Reducing engine’s IR signature may reduce performance (USA helos: -80% IR, -2% thrust. USAF turbofans: -80% IR, +75% drag count)
  - Aircraft integration (weight, balance, actuation system)
  - Paint may have weight and maintenance benefits
  - Some paint schemes may raise safety concerns
Mitigation Option: Tamper-proofing MANPADs

- Incorporate Permissive Action Links (PALs) in design of new MANPADs
  - Microchip-based, cryptographical “trigger locks”

Considerations

- Cultural impediments
- May raise costs for U.S. weapons
- May threaten legitimate exports unless multi-lateral
- Retrofitting proliferated missiles a challenge
Mitigation Option: Arms Control

- Coordinated international attempts to limit proliferation
  - Multilateral and unilateral export controls
  - Sting operations
  - MANPADs “Buy Back Programs”

- Considerations
  - “An ounce of prevention is worth a pound of cure”
  - Large number of MANPADS already proliferated
  - Can focus on biggest threats (e.g. CLOS, dual mode seekers)
  - No multi-lateral arms control treaty -- no international consensus
  - Informal arrangements a start, but often lack “teeth”
  - Effect of “buy back” questionable in light of well funded terrorists
Summary

Threat
- MANPADS are cheap, widely proliferated, easy to use and conceal, and potentially lethal to all classes of aircraft

Mitigation Options
- No single-point solution
- Menu of options which are situationally driven
Back Ups
Capabilities/Characteristics

- Engagement times: 3 to 10 seconds
- Altitudes up to ~15,000 ft
- Ranges: out to ~5 miles
- Cost: $5,000-$80,000
- Guidance
  - Infra Red (IR)
  - Command Line of Sight (Laser, RF)
- High “surprise quotient”
- Potentially lethal to all classes of aircraft
Select Producers/SFM

China
- HN-5
- HN-5A
- HN-5B
- Vanguard
- QW-2
- FN-6

Bulgaria
- SA-7B
- SA-14
- SA-16

Egypt
- Sakr Eye

France
- Mistral

Japan
- Keiko

Pakistan
- Anza I
- Anza II

Romania
- SA-7B

Russia
- SA-7A
- SA-7B
- SA-14
- SA-16
- SA-18

Serbia
- SA-7B
- Strela-2M/A

Sweden
- RBS-70

Ukraine
- SA-18

United Kingdom
- Blowpipe
- Javelin
- Starstreak

United States
- Redeye
- Stinger
- Stinger RMP
- Stinger Block 1

up to 700,000 produced worldwide
Proliferation

- 27 militia groups and terrorist groups estimated to have SFMs
- SFM have attractive attributes: cheap, easy to conceal, easy to use, effective

Source: BAE Systems
Proliferation

- No multi-lateral arms control treaty
  - Wassenaar Agreement attempts to provide transparency
  - Country-by-country export controls

- State sponsors of terrorism
  - Direct transfer to terrorists

- Diversion of legitimate export
  - Hundreds of *Stingers* and *Blowpipes* given to Afghan rebels in the 1980s unaccounted for
Proliferation

- **Black Markets/Poor Control and Accountability**
  - Former Soviet Union
  - Yemen
  - Iraq

- **Arms Dealers**
  - Virgin Islands: 10/30/02 FBI arrests 2 Pakistanis and 1 U.S. citizen trying to trade drugs for Stingers
  - Hong Kong: 11/06/02 three men with links to Al Qaeda tried to buy Stingers from FBI agents
  - NYC: 8/12/03 FBI arrests dealer trying to sell Russian SFMs
  - Saudi Arabia: 8/03 intercept of truckload of SFMs in Jeddah
Civil Aircraft Engagements
Estimates Vary

FBI estimates airliners hit at least 29 times causing <550 deaths

RAND: as many as 40 civil aircraft were shot down between 1975 and 1992; causing up to 760 deaths

CIA (1997 Report)
• 27 incidents
• > 400 casualties

## Threat: History of Military Use

<table>
<thead>
<tr>
<th>Conflict</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arab-Israeli Wars</td>
<td>Egypt damaged or shot down 36 Israeli aircraft with SA-7s; Syria shot down 11 aircraft</td>
</tr>
<tr>
<td>Vietnam</td>
<td>SA-7s credited with shooting down or damaging 204 U.S. and S. Vietnamese aircraft</td>
</tr>
<tr>
<td>Soviet Union/Afghanistan</td>
<td>Mujahadin downed 269 Soviet aircraft using 340 shoulder-fired SAMs</td>
</tr>
<tr>
<td>1991 Gulf War</td>
<td>12 of 29 Coalition aircraft lost due to MANPADs</td>
</tr>
<tr>
<td>Iraq (OIF)</td>
<td>??</td>
</tr>
</tbody>
</table>
Select Reports of Terrorist Use/Attempted Use

- **01/73 Rome, Italy**
  - *Black September* smuggles 14 SA-7’s into Italy
  - Caught minutes before Israeli PM Meir’s plane lands
- **05/02 Prince Sultan AB, Saudi Arabia**
  - Sudanese terrorist attempts to fire two SA-7s at U.S. aircraft
- **11/28/02 Mombassa, Kenya**
  - Two SA-7s fired at an Israeli airliner on take off
- **09/06/03 Baghdad, Iraq**
  - Two SFMs fired at C-141 aircraft on take off
- **11/23/03**
  - DHL A300B4-200 freighter hit by SA-7