Protection of semi-military and civil aircraft

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Göteborg, April 12th, 2007
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- Some MANPADS characteristics
- Challenges in protecting civil and semi-military aircraft against MANPADS
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The threats and associated protection concepts

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    - 911
- Protection
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  - Passenger screening
  - Intelligence
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The threats and associated protection concepts

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  - Typical scenario
    - Lockerbie
- Protection
  - Passenger screening
  - Cargo screening
  - Intelligence
The threats and associated protection concepts

- Cyber related threats
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    - Passive listening
    - Closing line
    - Altering line
    - Substituting line
      - HF
      - VHF
      - SATCOM
      - BEACON
      - TCAS
      - ATC
      - DGPS
      - ILS
      - MLS
      - VOR
      - DME
  
- Protection
  - Safeguarding ground based assets
  - Jamming resistant antennae (directed)
The threats and associated protection concepts

- Radiation threats
  - Typical scenario
    - Eye damaging lasers
      - Incident has occurred!
    - High Power Microwave
      - Futuristic
  - Protection
    - Likely none required
The threats and associated protection concepts

- Unguided weapons
  - Typical scenario
    - Small caliber gunfire
    - .50 cal anti-air gun
    - Rocket Propelled Grenades
    - In general limited range weaponry
  - Protection
    - Intelligence
    - Armor
    - Restricted access to airport vicinities
    - The dumbest weapons are often the most difficult to counter…
The threats and associated protection concepts

- Guided weapons
  - Typical scenario
    - Command to Line of Sight
    - Beam Riders
    - MANPADS
  - Protection
    - Arms control
    - Intelligence
    - Susceptibility reduction – signature management
    - Vulnerability reduction
      - A – Armor
      - B – Bury
      - C – Consolidate
      - D – Duplicate
      - E – Eliminate
      - F – Fly very high
    - Counter-MANPADS-system
Man-Portable Air Defense System facts and figures

- **IR MANPADS**
  - Light weight, compact, cheap
  - Relatively easy to use
  - Generally small warhead
  - Generally contact fuse – has to make direct hit
  - Simpler models widely proliferated
  - Likely multiple launches in attack
MANPADS facts and figures

Countries with IR MANPADS
- Over 700,000 MANPADS have been produced worldwide since the 1970s\(^1\)
- 35 MANPADS engagements over 10 years, 24 a/c downed, 500 people killed\(^4\)

Location of “non-state” organizations with IR MANPADS
- 150,000 MANPADS estimated in the hands of “non-state” organizations\(^2\)
- Prices as low as 5,000 $US\(^3\)

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\(^1\) CSIS, “Transnational Threats Update,” Vol. 1, No. 10, 2003
\(^2\) Jane’s Intelligence review February 12, 2003
\(^3\) Jane’s Terrorism and Insurgency Centre, “Proliferation of MANPADS and the Threat to Civil Aviation”, August 13, 2003
Manpads attack timeline

- Aircraft rolls down the runway
- Target aircraft picked; prepare missile, activate battery and spin-up missile seeker
- Tracking, lock-on and pre-launch confirmation
- Launch of missile
- MAW detects UV emissions, possible missile
- MAW track possible missile
- Missile confirmed
- Calculate optimum decoy timing
- Dispense decoys
Examples of MANPADS attacks

- In Nov 2002 two SA-7 missiles was fired against an Israeli Boeing 767 taking off from Mombasa
- In Nov 2003 one SA-7 and one SA-14 was fired against DHL A300 taking off from Baghdad
MANPADS inflicted damage to DHL A300

MANPADS damage on the Airbus A300
## Challenges – differences

<table>
<thead>
<tr>
<th>Property</th>
<th>Military</th>
<th>Head-of-state/VIP</th>
<th>Commercial</th>
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<tbody>
<tr>
<td>Threat</td>
<td>Various, hi-end</td>
<td>MANPADS</td>
<td>MANPADS</td>
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<tr>
<td>Tactics</td>
<td>Various employed</td>
<td>Limited employment</td>
<td>Not employed</td>
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<tr>
<td>Effectiveness</td>
<td>High probability low to medium consequence</td>
<td>Low probability medium to high consequence</td>
<td>Low probability high consequence</td>
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<tr>
<td>Safety requirements</td>
<td>Not low but not prioritized</td>
<td>Very high – civil environment</td>
<td>Very high – civil environment</td>
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<tr>
<td>Cost</td>
<td>High costs accepted</td>
<td>High costs generally accepted</td>
<td>Airlines have thin margins!</td>
</tr>
<tr>
<td>Tempo of operation</td>
<td>Hundreds of flight hours per annum</td>
<td>Hundreds of flight hours per annum</td>
<td>Thousands of flight hours per annum</td>
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<tr>
<td>Reliability</td>
<td>Typically hundreds of hours</td>
<td>Typically thousands of hours</td>
<td>Typically thousands of hours</td>
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<tr>
<td>Operational environment</td>
<td>Extreme</td>
<td>Benign</td>
<td>Benign</td>
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<tr>
<td>Exportability</td>
<td>No requirement</td>
<td>May be required</td>
<td>Required</td>
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<tr>
<td>Support infrastructure</td>
<td>Specialized, mobile</td>
<td>Civil, generic</td>
<td>Civil, generic</td>
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</table>
Capability

- Capability = tactics + technology
- Only small possibility to employ tactics in civil context;
  - No or small maneuverability
  - No possibility to alter throttle settings
  - Difficult to be unpredictable
  - Difficult to employ spiral takeoffs etc
Counter-MANPADS-systems

- Land based systems – Point defense of airports
  - High energy lasers
  - High power microwave

- Aircraft based systems – Point defense of aircraft
  - Missile detection systems
  - DIRCM
  - CLIRCM
  - Hard kill DIRCM
  - Pyrotechnic flare based systems
  - Pyrophoric flare based systems
Counter-MANPADS-systems

- Land based directed energy systems
  - High power microwave
  - High energy laser
  - Point defense of airports
    - Ground based grid of sensors
    - Ground based grid of directed energy weapons
  - Limited geographic coverage;
    - Footprint of several hundred km²
- Safety issues
Counter-MANPADS-systems

- **Missile Detection Systems**
  - None (or the “old eye-ball”)
    - Pre-emptive dispensing of flares inhibits missile seeker target acquisition
    - Not suitable to civil aviation
  - **Active RF**
    - Measures rough direction, closing speed (Time To Intercept)
    - Sensitive to false alarms in some environments
    - Interoperability concerns
  - **Passive UV**
    - Imaging system measuring UV radiation from missile plume
    - Operates in UV solar blind spectrum
    - False sources include welding, sparks and flashes and some outdoor lamps
    - Measures direction, estimates time to intercept
    - Limited range (enough for MANPADS)
  - **Passive IR**
    - Imaging system measuring IR from missile plume and tracking radome emissions
    - Measures direction, estimates time to intercept
    - Has to cope with massive amount of man-made IR sources
  - **Sensor fusion and processing**
Counter-MANPADS-systems

- **DIRCM**
  - Laser based DIRCM
    - Detection sensors
    - Tracking sensors
    - Turret with laser slewed with tracking sensor data
    - Modulated light induces false steer commands in missile seeker; generic jam code
    - If powerful enough, may cause stray light in seeker
  - Is not a true decoy, i.e. may attract missile under some circumstances
  - Has problems with multiple missile launches due to timing issues
  - Experiences problems with modern missile seekers
  - Technology under ITAR restrictions
Counter-MANPADS-systems

- **CLIRCM**
  - Laser based DIRCM
    - Detection sensors
    - Tracking sensors
    - Turret with laser slewed with tracking sensor data
    - Seeker characteristics measured by laser, e.g. reticle frequency
    - Modulated light induces false steer commands in missile seeker; jamcode adapted to threat
  - Is not a true decoy, i.e. may attract missile under some circumstances
  - Has problems with multiple missile launches due to timing issues; though adapted jam codes may provide quicker jamming sequence
  - Experiences problems with modern missile seekers
  - Technology under ITAR restrictions
Counter-MANPADS-systems

- Hard kill DIRCM
  - Not operational or demonstrated
  - Energy focused by missile optics to detector which pops
  - Not mature
    - Requires lots of power
    - Has to operate in several bands
    - Repeat rate issues
Counter-MANPADS-systems

- Pyrotechnic flare based system
- Legacy military technology
  - Various types of flares exist
    - Adapted to specific threats
      - Spectral characteristics
      - Kinematic characteristics
      - Temporal characteristics
    - Generally employed in “cocktails”
    - Masses typically 0.2-1 kg
    - Ejection velocities typically 10-40 m/s
  - Technology under ITAR restrictions
  - Safety issues
Counter-MANPADS-systems

- Pyrophoric decoy based system
  - Electromechanically dispensed pyrophoric decoys
  - No pyrotechnics
  - Medium temperature area decoy competes with engine signature(s)
  - Very low visual signature and not audible when dispensed
  - Masses in range of 50 g
  - Ejection velocities 2 m/s
  - Safe!