Civil Aircraft Security Against Manpads

Aeronautics Specific Targeted Research Project (STREP)
of the European Sixth Framework Program (FP6)

30th March 2011
Presentation Plan

- Introduction
- The threat
- CASAM project background
- Objectives and Work description
- System presentation & tests results
- Simulations
- Mechanical implementation analysis
- Elements of Life cycle costs
- Regulation
- Other DIRCM
- Synthesis and analysis of CASAM results
- Consideration for roadmap and priorities
SA-14 Gremlin:

Russian made, it is a portable missile thought to be in the hands of many would-be terrorists around the world. This missile is a serious threat to commercial aircraft on takeoffs and landings, and when flying below 18,000 feet.

- Crew of one needed to acquire target and fire.
- Reload time 25 seconds.
- Maximum range: 6,000 meters, 18,000 feet.
- Maximum altitude: 6,000 meters, 18,000 feet.
- Missile speed: 600 meters (1,968 feet) per second.
- Guidance: Passive heat tracking (guides toward heat such as projected by an aircraft engine).
- Fuse type: Explodes on contact.
- Warhead: Fragmentary.
The threat -1-

Threat Exceeds 500,000 IR Missiles World-wide

1960s
Uncooled/Cooled Spin Scan

1970s/80s
Cooled Con Scan

1980s/90s
Cross Array/Rosette Flare CCMs

2000
Scanning Imagers

2005
1st Generation Imagers

2010
2nd Generation Spectral Imagers

<= 4th generation IR seekers

<= 3rd generation IR seekers

<= 2nd generation IR seekers

<= 1st generation IR seekers

SA-7

Stinger

Mistral
## The threat -2-

### Non-State Groups with MANPADS

Proliferation of MANPADS among Selected Non-State Groups

Different MANPADS classes available on black and grey markets

- **1st gen infrared** – Reticle Scan, SA–7
- **2nd gen infrared** – Conical scan SA–14, SA–16, Basic Stinger
- **3rd gen infrared** – Pseudo imaging, SA–18
- **CG** – Command guided, Blowpipe

<table>
<thead>
<tr>
<th>Group</th>
<th>1st gen</th>
<th>2nd gen</th>
<th>3rd gen</th>
<th>CG</th>
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</thead>
<tbody>
<tr>
<td>Al Qaeda</td>
<td><img src="image" alt="Confirmed" /></td>
<td><img src="image" alt="Confirmed" /></td>
<td><img src="image" alt="Probable" /></td>
<td><img src="image" alt="Probable" /></td>
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<tr>
<td>Chechen rebels</td>
<td><img src="image" alt="Confirmed" /></td>
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<tr>
<td>Taliban</td>
<td><img src="image" alt="Confirmed" /></td>
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<td>Tamil Tigers</td>
<td><img src="image" alt="Confirmed" /></td>
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<td>Hezbollah</td>
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RAND Corporation: Protecting Commercial Aviation Against the Shoulder-Fired Missile Threat (2005)
As part of mass transportation systems, commercial aircraft are a potential target for terrorists because they represent one of the best achievements of our society. As a result, an attack would have a large psychological impact on people and economic activity.

Several European Commission-funded research and technology programs, such as SAFEE and PALMA, are dedicated to technologies and systems that will be implemented onboard aircraft in the near future to increase the security of commercial flights.

One of these programs, CASAM, was focusing on a potential solution to reduce aircraft vulnerability against Man Portable Air Defense Systems (MANPADS) during takeoff, ascent and landing.

A specific onboard jamming system has been developed, meeting stringent yet competitive requirements that deal with high reliability, low cost and minimal installation constraints.
Background -2-

Major European actors:
14 companies and 4 research centres from 6 countries

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>SAGEM</td>
<td>FR</td>
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<tr>
<td>EADS Deutschland GmbH</td>
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<td>Diehl BGT Defence &amp; Co</td>
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<tr>
<td>THALES Optronique SA</td>
<td>FR</td>
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<td>INEGI-INE</td>
<td>PT</td>
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<td>A. BRITO</td>
<td>PT</td>
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<td>Clyde &amp; Co- Beaumont Aviation</td>
<td>UK</td>
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<tr>
<td>Institute for Economic Research-IER</td>
<td>SI</td>
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<tr>
<td>ONERA</td>
<td>FR</td>
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<td>ADRIA AIRWAYS</td>
<td>SI</td>
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<td>LHT</td>
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<td>KEOPSYS</td>
<td>FR</td>
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<td>LASERDIAGNOSTIC INSTRUMENTS</td>
<td>EE</td>
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<td>DLR</td>
<td>DE</td>
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<td>FGAN-FOM</td>
<td>DE</td>
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<tr>
<td>Hellenic Aerospace Industry- HAI</td>
<td>GR</td>
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<tr>
<td>THALES Research &amp; Technology</td>
<td>FR</td>
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<tr>
<td>ALCATEL THALES III-V Labs</td>
<td>FR</td>
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</tbody>
</table>

- Contract AST5-CT-2006-030817
- Total cost: 8.65 M€
- EC contribution: 4.54 M€
- From June 1st 2006 to June 30th 2009
Objectives

The overall objective of the CASAM Project was to design and validate a closed-loop, laser-based DIRCM (Directed IR Countermeasure) module for jamming fired missiles. It had to comply with commercial air transportation constraints, including the normal air traffic control rules. For example, the following aspects have been considered:

- Environmental friendliness for ground objects and inhabitants close to airports, aircraft safety (maintenance, handling and usage) and high efficiency against the recognized threats
- Upgradability for further and future disseminated threats
- Adherence to commercial operation budgets and processes

Even if military DIRCM already exist, they are different from what would be a “civil DIRCM”:

- Military DIRCM are driven by operational needs
- Civil DIRCM are mainly driven by standardisation and regulation (not defined today) and cost is a major design driver as well
Technological breakthroughs

In lasers, optics, electro-mechanics and processing to identify an efficient and competitive DIRCM system for use on commercial aircraft

- low total **volume**, low **drag**, low **mass**, low **power consumption**, low **life-cycle cost**, high **reliability** and no induced risk on the ground during takeoff and landing.

- Reducing **optronics volume, mass and costs**. The opto-mechanical turret has achieved outstanding performance in **steering and stabilization**. New **focal plane arrays** (imagery sensor) have integrated **passive and active detection modes**.

- New, efficient **laser-technology** approaches, including fiber lasers and simpler frequency conversion modules (OPO), as well as directly-emitting, mid-infrared semiconductor lasers.
Countering MANPADS in Commercial Aviation -1-

- Implement an onboard protection system
  - Missile Approach Warning Subsystem
  - Countermeasure Device
  - Countermeasure computer

Onboard Countermeasure Devices
- Flares (present a false IR target);
- Jammers (create false guidance signals)
  - fixed lamp based;
  - directed lamp based;
  - laser based.
Vulnerability factors:
- Jam missile seeker.
- Dazzle missile seeker.
- Destroy seeker FPA.
- Heat and detonate warhead.
- Destroy missile structure.

<table>
<thead>
<tr>
<th></th>
<th>1st Generation</th>
<th>2nd Generation</th>
<th>3rd Generation</th>
<th>4th Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLARES</td>
<td>**</td>
<td>*</td>
<td>-</td>
<td>-</td>
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<tr>
<td>ADAPTED FLARES</td>
<td>**</td>
<td>**</td>
<td>*</td>
<td>-</td>
</tr>
<tr>
<td>MODULATED LAMP</td>
<td>**</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>IRCM/DIRC</td>
<td>**</td>
<td>**</td>
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<td>**</td>
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<tr>
<td>LASER DIRC</td>
<td>**</td>
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</table>
DIRCM: The ways the System would work

- Detect attacking missile
- Passive tracking
- Active tracking
- Seeker identification
- Seeker jamming
System requirements

- **multi-threat** (defeat 2 quite-simultaneously fired MANPADS)

- **cost** (single turret solution)
  - Highly dynamic and accurate steerable Turret,
  - wide field of view for the turret,
  - precise active missile tracking,
  - missile seeker category identification,
  - right choice of beam jamming modulation

- First detected Threat must be jammed asap to keep a chance to defeat the incoming second one as well
IR signatures

- Experimental database of some 10000 fully calibrated & referenced IR signatures: 3 a/c types, (A320, B747, ATR72), landing and take off, from front, side and back view and in SWIR and MWIR bands.

- IR signatures at aircraft level, for a typical scenario, can be estimated with an accuracy better than 30%.
Civil DIRCM technical architecture -1-

- Closed loop operating system
- Dual band jamming laser

Diagram:
- Aircraft
- Missile approach warning sensor
- Control computer
- Active & passive tracking sensor
- Command & control electronic
- Beam director
- Laser head
- Pump laser
- Power supply
- Thermal & pressure control
- Turret
Civil DIRCM technical architecture -2-

OPO Module

Rotor
Stator
Traveling Wave
Passive and active tracking

- Large input power range (low level → laser)
- LSW-SSW commutation < 4 frames
- SSW 64 x 32 > 4 kHz
Ground test installation

Sledge:
\[ \omega_{\text{max}} = 0.9 \, ^\circ/s \]

2- Axes Table:
- Sin Wave Az/El
- \( f = 0.2 \, \text{Hz}; \ A = 0.2 \, \text{rad} \)

CASAM Turret

Laser target simulator movement

Seeker simulation

380 m

34 m
Ground tests

Sagem R&T / Aerodays 2011 Madrid / 30th March 2011

[Diagram showing various components and systems related to ground tests, including laser source, electronics, processing computers, and other equipment.]
Simulations -2-
Demonstration of various realistic scenarios

- two simultaneously launched missiles
- missile “short distance launch”
- optical obscurcation case
- late missile locking on target

Conclusion of demonstration:

- appropriate to simulate representative DIRCM system & missile launch scenarios
- useful tool to evaluate performance and success probabilities (statistical studies)
- adequate to support the performance specifications for an operational product
Mechanical implementation analysis
Elements of Life Cycle Cost -1-

1,9 billion € (300 aircrafts) to 15,1 billion € (3,000 aircrafts) cost of DIRCM

compared to

139 billion € to 238 billion € of costs of potential MANPADS attack(s) on commercial airliner(s)
### Elements of Life Cycle Cost -2-

#### COST per FLIGHT HOUR (FH)

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1: 300 aircrafts in 3 years</th>
<th>Scenario 2: 3000 aircrafts in 10 years</th>
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<tbody>
<tr>
<td></td>
<td>A320</td>
<td>A340</td>
</tr>
<tr>
<td>I. Component &amp; Installation</td>
<td>58,42 €</td>
<td>58,42 €</td>
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<tr>
<td>II. Training</td>
<td>0,46 €</td>
<td>0,46 €</td>
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<tr>
<td>III. Operational</td>
<td>135,44 €</td>
<td>82,75 €</td>
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<tr>
<td>IV. Upgrades</td>
<td>21,56 €</td>
<td>21,56 €</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>215,88 €</td>
<td>163,18 €</td>
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#### COST per FLIGHT CYCLE (FC)

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<tbody>
<tr>
<td></td>
<td>A320</td>
<td>A340</td>
</tr>
<tr>
<td>I. Component &amp; Installation</td>
<td>87,63 €</td>
<td>408,92 €</td>
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<tr>
<td>II. Training</td>
<td>0,69 €</td>
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<tr>
<td>III. Operational</td>
<td>203,17 €</td>
<td>579,22 €</td>
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<tr>
<td>IV. Upgrades</td>
<td>32,33 €</td>
<td>150,89 €</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>323,81 €</td>
<td>1,142,24 €</td>
</tr>
</tbody>
</table>

#### COST per TICKET (per passanger per flight)

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1: 300 aircrafts in 3 years</th>
<th>Scenario 2: 3000 aircrafts in 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A320</td>
<td>A340</td>
</tr>
<tr>
<td>Average number of passengers 'on-board'</td>
<td>122</td>
<td>246</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>2,65 €</td>
<td>4,64 €</td>
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Certification and Regulation issues

- Mandating of counter-MANPADS systems in commercial air transport
- “Airworthiness” of counter-MANPADS systems
- Operational regulation

Transfer of Technology Controls issues

- Military articles and technology
- Dual Use technology
### Other DIRCM

#### BAE Systems‘s Jet Eye™
- Evolved from U.S. Army Advanced Threat Infrared Countermeasures (ATIRCM) Program
- Utilizes distributed component approach
- Commercialized version consists of 12 Line Replacement Units (LRU)

#### Northrop Grumman‘s Guardian™
- Evolved from U.S. Air Force Large Aircraft Infrared Countermeasures (LAIRCM) Program
- External pod contains most components
- Commercial version consists of 4 LRUs
Synthesis & analysis of CASAM results -1-  

CASAM TEST ARTICLE  
Closed-looped dual-band laser based DIRCM  

Operational context  
System specification, mission profile  
Performance simulation  
Transverse studies: General Environment, System Analysis  
Economics, Life Cycle Cost  
Aircraft integration  
End User Environment  
Integrated Logistic Support  
Regulatory context  

Over 30 documents produced by 12 technical Work packages
Synthesis & analysis of CASAM results -2-

- System analyses significant steps
  - Functional and interfaces specifications for civilian DIRCM
  - Demonstration of a global system simulation taking into account most critical elements and allowing performance study with representative scenarios & threats
  ⇒ support for future product design

- Demonstrator significant steps
  - Demonstration of a 2-colour laser source compliant with its specifications for civilian DIRCM
  - Demonstration of the feasibility of an agile turret performing passive and active acquisition and tracking (on going)
  ⇒ roadmaps for technologies

- Significant steps about end user & general environment issues
  - Aircraft integration: possible location and implementation
  - Integrated Logistic Support recommendations
  - Regulation needs and priorities
  - Consolidated DIRCM prices
Considerations for roadmap and priorities

- **Need of a political will as driving force**
  - Create political awareness and incite public policy to face US pressure in regulation and legislation (risk of USA “de facto” legislation)

- **Urgent need of responsibility sharing and regulation framework**
  - Responsibilities have to be allocated between States, Aviation authorities, airline companies, equipment manufacturers: specification and performances, validation, export rules, possible collateral damage/civil population security…
  - Rules and standards compatible with civilian DIRCM have to be defined

- **Need of public funding**
  - Due to today lack of identified market, industrial companies cannot initiate investment
  - Europe should reach a sufficient level of technology readiness, to enable a balanced discussion with the USA
Roadmap to civilian DIRCM production for end users

**User requirements**
- Simulation with actual classified data (non generic)
- System specifications
- Dual technologies specifications
- Eligible dual technologies selection and development
- Qualification plan
- Test means specification derived from military

**Operational product**
- 2019 production

**Certification**
- Airworthiness and safety
- Efficiency label granting
- Performance qualification
- Ground and flight demonstration

**Qualification**
- 2017

**Prototyping**
- 2016
- Dual technology integration
- Reliability demonstration

**Development**
- TRL 6
- 2011
- Detailed specifications
- Dual technologies development

**Responsibility allocations**
- 2011
- Political issues
  - Installation obligation
  - Classified data & sovereignty issues
- Military/police issues
  - Level of protection efficiency against threats
  - Level of performance qualification
  - Classified data protection
  - Exportation clearance & enforcement via maintenance
- Civilian aviation authority issues
  - Legal responsibility sharing between all actors
  - Level of certification
  - Rules of maintenance
- Aircraft industry issues
  - Standards

**Technologies readiness**
- 2009

**CASAM**
- 2009

**Simulations and specifications**
- 2011
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