

MUSIC®

MUlti Spectral Infrared Countermeasure

Andrew Lovett M.Sc M.B.A
Director
Marketing and Business Development
EOCM Division, Elop

ELOP Proprietary

Elop is the leading military electro-optics company in Israel. Elop was founded in 1937 and has been at the forefront of electro-optics technology ever since.

The Threat

- Heat Seeking Ground to Air Missiles also known as MANPADS (Man Portable Air Defense Systems)
- Russian - SA7, SA14, SA16, SA18
- USA – Stinger Basic, POST and RMP
- France – Mistral
- China, Pakistan, Iran, etc.

The threat of MANPADS has been increasing steadily over the last 20 – 30 years and there have been numerous incidents in which missiles have been fired at aircraft and helicopters.

Proliferation

- Over 500,000 missiles worldwide
- Over 1,000 missiles in the hands of EL-Quaida and other terrorist groups



The proliferation of MANPADS is extremely wide. By some estimates there are more than 500,000 missiles world wide, of which a large number is out of governmental control.

MANPADS in Action

In the video we show the relative simplicity of MANPAD operation – the operator locates the target and then points the missile sight towards it. The missile seeker automatically acquires the target, notifies the operator with an audible signal and can then be launched towards it.

Basic Parameters

- Effective range 750 – 5000 meters
- Maximum flight time 10 – 12 seconds
- Warhead 1 Kg
- Velocity 2 Mach
- Effect on helicopter Fatal
- Effect on large aircraft Loss of one engine
Structural damage
Fatal

These are the basic parameters of a MANPAD and, as can be seen, the effect on an aircraft can be catastrophic. In the case of a large aircraft a non-fatal effect will usually only occur during landing.

Crash Landing of DHL Flight

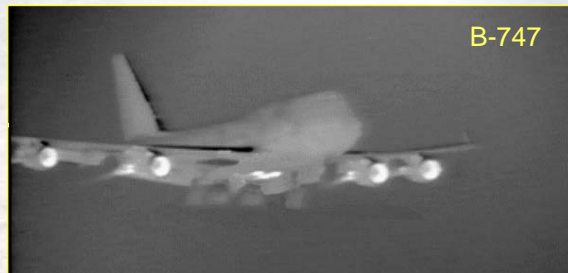


The DHL flight in Bagdad – superb pilot reaction and lots of luck.



The missile hit the wing, not the engine – that was the lucky part.

Aircraft Heat Sources



8

ELOP Proprietary

Aircraft have numerous sources of heat on which the missiles can lock – not only the engines.

On the Boeing 747 the air-conditioning output ducts are good heat sources.

Wavelengths

- SA-7 operates in Band I = 1.5 – 2.5 microns
- Most other missiles operate in Band IV = 3 – 5 microns
- Therefore a jamming system must operate simultaneously in both bands.

Some of the older systems jamming systems had an additional wavelength in Band II to counter the Redeye missile. This is no longer considered a threat.

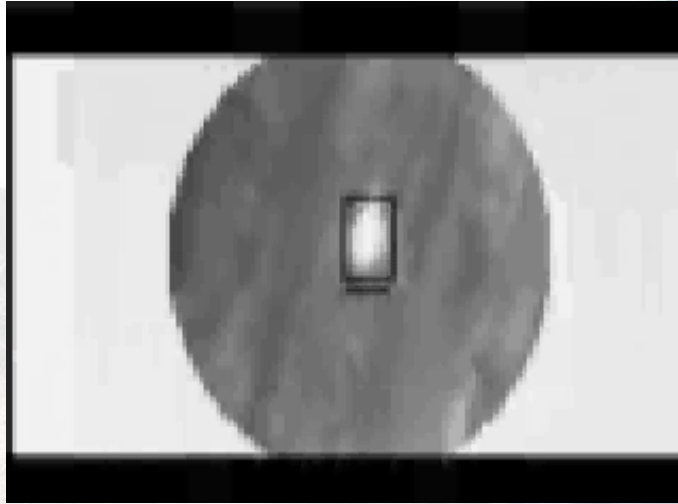
The Future Threat

- As more DIRCM systems are put into use, we will see the next generation of missiles appearing which will be immune to the present generation of DIRCM systems
- These will include:
 - Imaging IR Missiles
 - Additional detector wavelengths (e.g.LWIR)

This represents the usual competition between the weapon and the counter-measure. When a counter-measure (CM) is developed for a weapon, a counter-counter-measure (CCM) is added to the weapon and so on.

In the case of a DIRCM system, it is important to be able to upgrade the capabilities of the system to meet new threats.

Imaging Missile



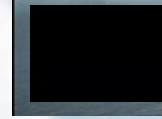
11

ELOP Proprietary

This video shows the imaging seeker of an air-air missile in operation.

Countering Technology

- Flares
 - Flare resistant missiles
 - Life Cycle Cost (LCC)



The oldest type of counter measure and the one with the greatest proliferation is the flare. With the appearance of missiles which have CCM capabilities against flares, it is clear that better solutions are required.

Countering Technology

- **Black Body IRCM**
 - Limited protection and performance
 - High power requirement
 - Obsolete technology
 - ALQ-144, Matador



ALQ-144

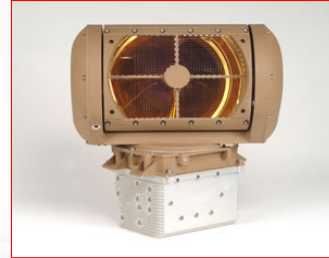


Matador
ALQ-204

Black body IRCM were developed to avoid the logistics required by flares. Again, because of advances in missile technology, their performance is limited.

Countering Technology

- Lamp Based DIRCM
 - Low jammer energy
 - Suitable only for small platforms
 - Poor reliability
 - In case of false alarm discloses platform location



Helistar/Jamair



ELOP Proprietary

Lamp based DIRCM were the first systems to direct a jamming beam at the missile itself. Because of inherent limitations of the lamp based systems, their use was limited mainly to smaller helicopters.

Countering Technology

- **Laser Based DIRCM**
 - Reliability
 - Weight
 - Size
 - Cost



Nemesis AAQ-24

In order to enable protection of larger platforms, the lamp in the DIRCM system was replaced with a laser. This enabled more power to be concentrated on the missile seeker.

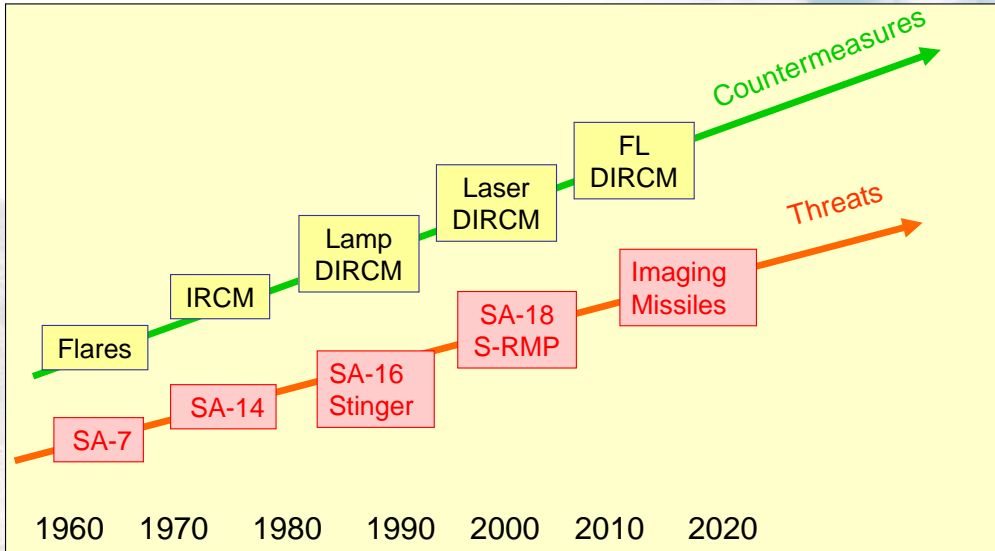
Summary of Limitations of DIRCM Systems

- Size and Weight
- Reliability
- Upgradeability
- Cost
- Export Restrictions

Use New Technology

The limitations of the various types of DIRCM systems prompted Elop to implement new technologies, that would enable building a smaller, lighter and more reliable DIRCM system. This led to the development of the Fiber Laser DIRCM system - MUSIC® .

Technological Developments



17

ELOP Proprietary

The technologies used for countering MANPADS have developed in step with advances in the missiles themselves. As each new countering technology was implemented, a new counter-counter technique was added to the missiles.

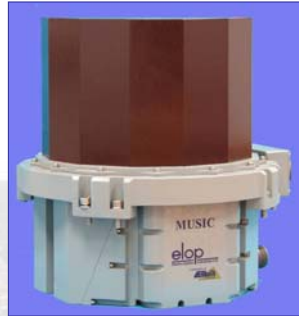
Technologies

The Power of Vision

- MUSIC® is based on a number of technological developments
- Dynamic Mirror Turret
 - Decouples sensors from line of sight pointing
 - Enables high speed target acquisition and tracking
 - Low weight
- Fiber Laser
 - Separates laser power generator from output
 - Enables multiple wavelengths to be generated
 - Supports upgradeability
- Thermal Camera
 - High frame rate for rapid acquisition and accurate tracking

This slide shows the three technologies that were developed and integrated into the MUSIC® Fiber Laser DIRCM system.

Mirror Turret



Moving

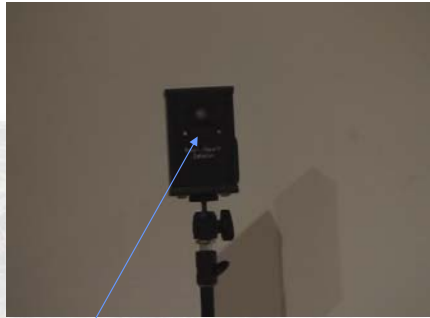


Stationary

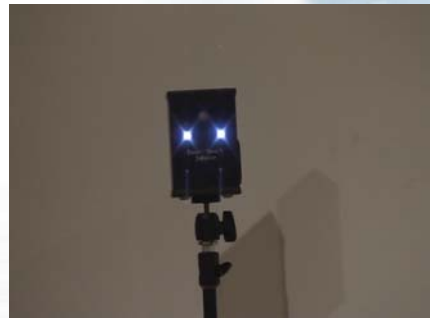
Rotation Speed: $>1000^\circ/\text{sec}$
180° Jump: 0.3 sec

The Mirror Turret has no external moving parts and is completely sealed by the dome. The only internal moving part is the mirror assembly. This enables a very high rotation speed of over 1000°/second to be obtained.

Seeker Simulator



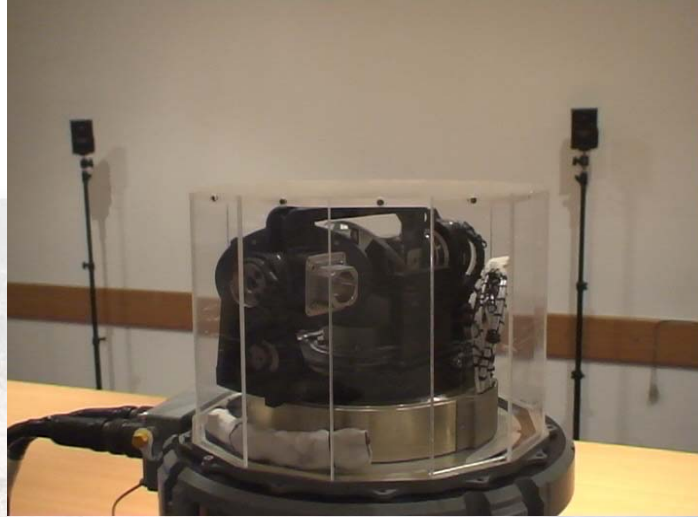
IR Detector



Laser Signal Detected

In order to test the system in the laboratory and in field tests we developed a seeker simulator which is sensitive to the laser wavelengths and has a similar effective optical aperture to the missile.

Mirror Turret

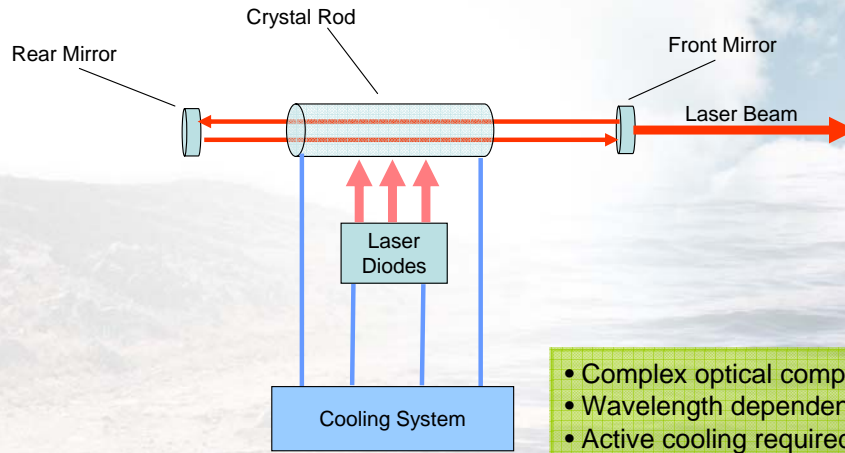


21

ELOP Proprietary

This video shows the rapid and accurate motion of the Mirror Turret when moving between two missiles.

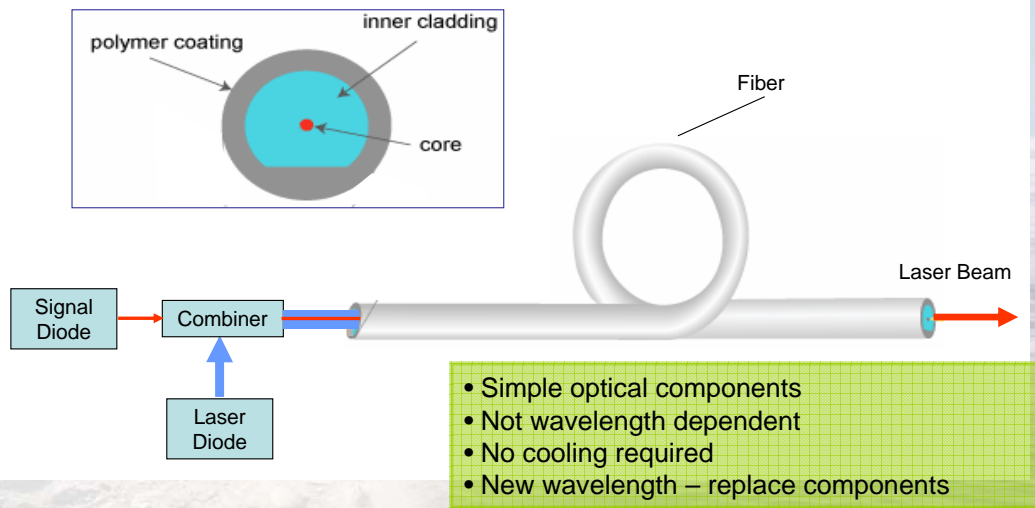
Diode Pumped Solid State Laser



- Complex optical components
- Wavelength dependent
- Active cooling required
- New wavelength – new laser

A diode pumped laser uses a special crystal rod to generate the laser beam. The laser contains many precision components and requires active cooling of the crystal and of the diodes.

Fiber Laser

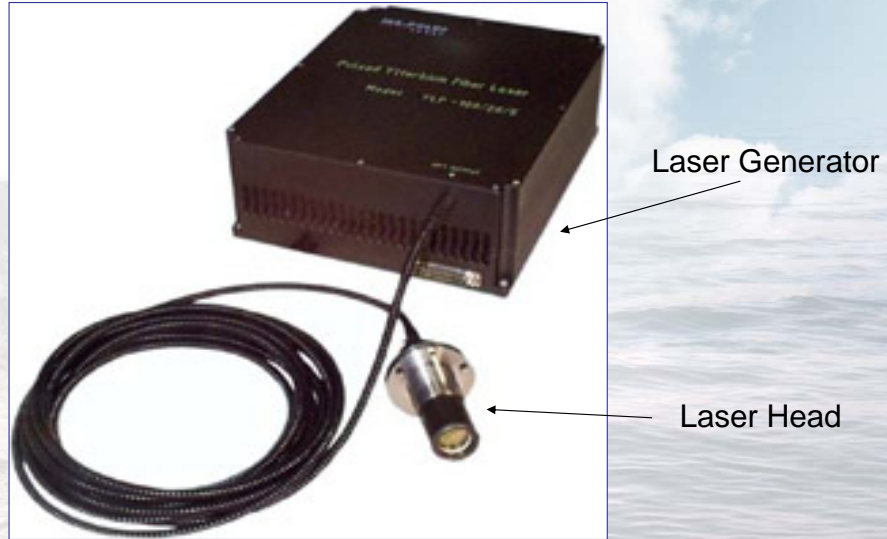


23

ELOP Proprietary

In a fiber laser the laser beam is generated within a special optical fiber. Because of the efficiency of the process no cooling of the fiber is necessary and fewer optical components are required.

Fiber Laser



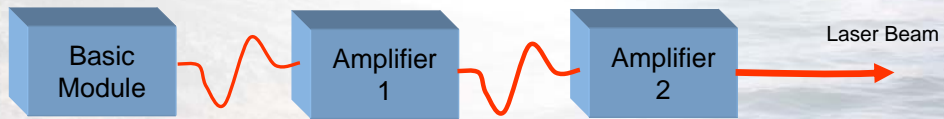
24

ELOP Proprietary

In a fiber laser it is possible to separate the laser generation part from the laser output thereby simplifying the DIRCM installation on platforms such as helicopters. The Laser Generator and the Laser Head are connected by an optical fiber.

Fiber Laser Amplification

- Fiber amplifiers can be cascaded to generate higher power outputs



Fiber lasers are in effect laser amplifiers which can be cascaded in order to generate higher levels of power.

Thermal Camera

- Detects, acquires and tracks the missile
- Requires good sensitivity and wide dynamic range
- High frame rate used to shorten acquisition time and increase tracking loop accuracy
- The MUSIC[®] Thermal Camera operates at over 200 Hz

The Thermal Camera acquires and tracks the target. By using a high frame rate camera the acquisition time is shortened and tracking accuracy of the system is improved.

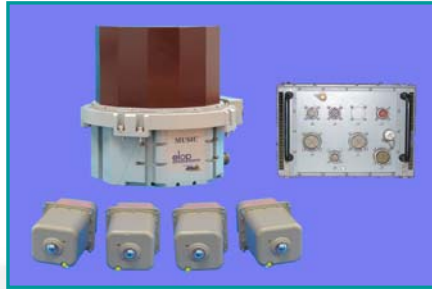
Missile Tracking



27

ELOP Proprietary

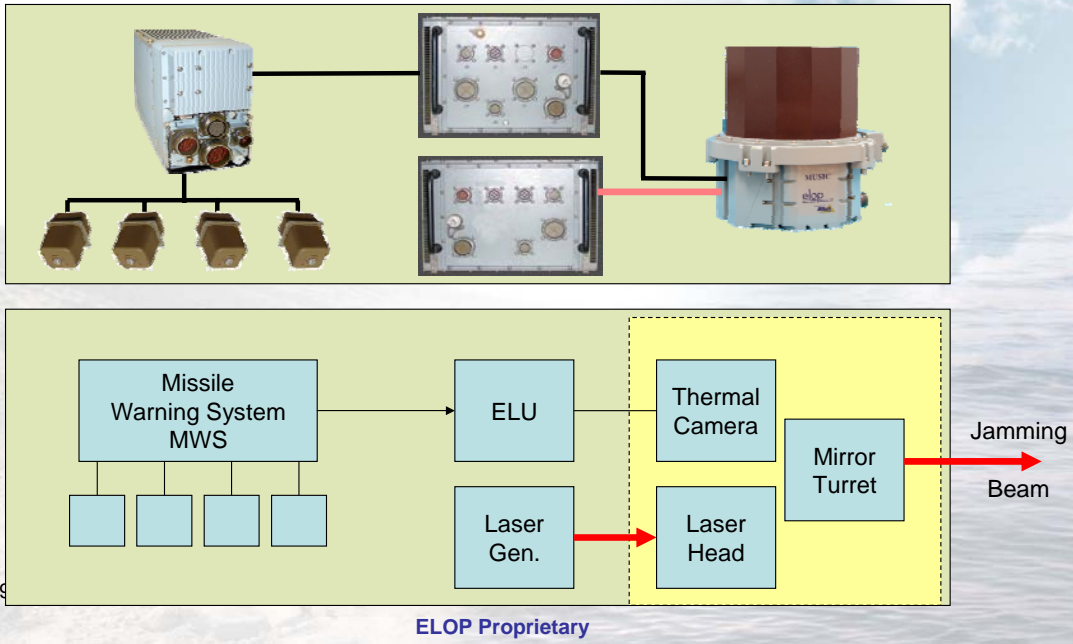
This video shows the automatic acquisition and tracking of a MANPAD missile by the Thermal Camera.



- **MUSIC**[®] is a compact and lightweight DIRCM system for protection of helicopters and aircraft from MANPADS.
- **MUSIC**[®] provides rapid and accurate detection, acquisition and jamming of IR missile threats.
- **MUSIC**[®] has high reliability and low LCC.

MUSIC® Configuration

The Power of Vision



ELOP Proprietary

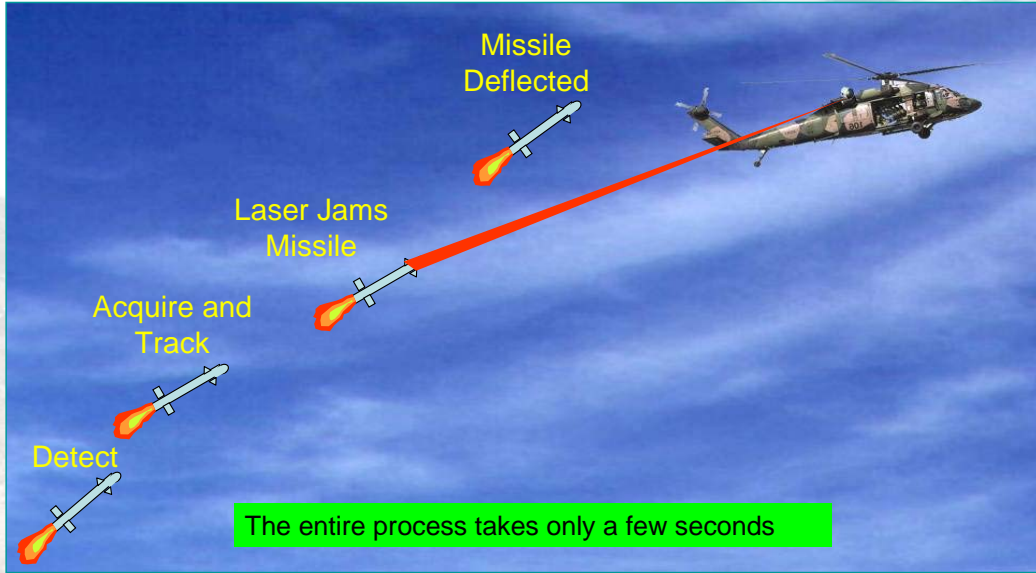
A full MUSIC® DIRCM system consists of a Missile Warning System (MWS) and a Jamming System. This slide shows the PAWS IR MWS with its four sensors as part of the system. The Jamming System consists of three units – the Laser Generator, the Electronic Unit (ELU) and the Jamming Turret.

Operational Requirement

- Protect aircraft and helicopters against MANPADS
- Operate with full performance during all aircraft maneuvers
- Provide a single solution for all platforms
- Minimize size, weight, drag, etc.
- Low LCC and high reliability
- 20 year life time – expandable to future threats

The operational requirement for the system was defined together with various customers from Israel and abroad.

Jamming Scenario



ELOP Proprietary

This shows the jamming process – detection of the missile by the MWS, acquisition and tracking by the Thermal Camera and jamming by the Fiber Laser.

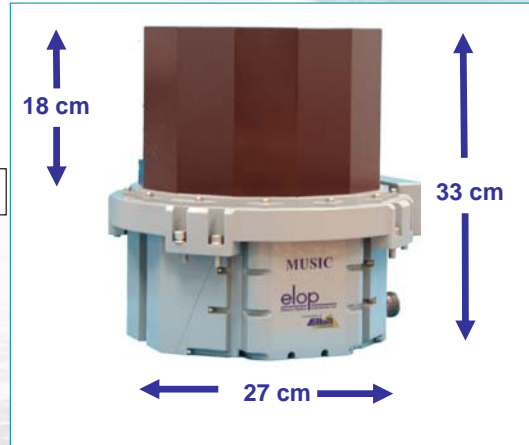
Physical Specification

Weight

- Jamming Turret	19 Kg
- Laser Generator	12 Kg
- Electronic Box	9 Kg
TOTAL	40 Kg

Power

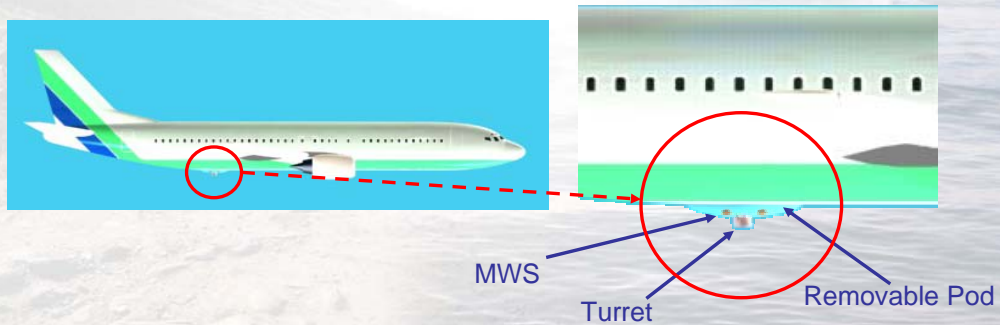
- Standby	500W
- Maximum (Laser Firing)	1500W



The small dimensions and low weight of the MUSIC® system enable it to be installed on and to protect all types of platforms from light helicopters up to large transport aircraft, and even commercial passenger aircraft.

Commercial and VIP Aircraft

- The MUSIC[®] system has been selected by the Israeli Government to protect the Israeli commercial aircraft
- The system will be installed in a removable pod under the aircraft



33

ELOP Proprietary

The selection of MUSIC[®] to protect the Israeli commercial fleet requires Elop to obtain Civil Aviation Authority certification for the system.

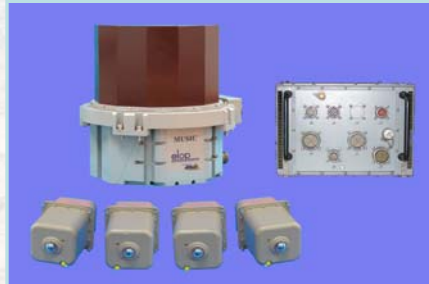
Status

- MUSIC® is in the final stages of FSD and is undergoing intensive testing
- Initial supplies to military customers will commence in the first half of 2009

The full scale development of the MUSIC® is nearing completion and the test program should be completed by the end of this year.

Summary

- MUSIC® provides the optimal solution for protecting platforms from MANPADS
- Integration of a fiber laser with a small turret and a high frame rate thermal camera provides high performance, reliability and efficiency with reduced LCC.
- Upgradeable for the next generation of threats



ELOP Proprietary

35

The integration of new technologies into the MUSIC® system has been successful and the resulting system will meet all operational and logistic requirements.